Economics of Gender, Risk and Labour in Horticultural Households in Senegal

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Economics of Gender, Risk and Labour in Horticultural Households in Senegal

Aïfa Fatimata NDOYE NIANE

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In honor, I dedicate this thesis to:

- My wonderful mother, Adja Coumba Fall
- My adorable husband, Ibrahima Niane
- My lovely daughters, Oumy Kalsoum and Awa …
- My nice mother in law, Adja Fatim Ka
- All my family

Table of Contents

List of Acronyms **10**

List of Tables 11

List of Figures 14

Chapter 1: Introduction 16

1.1. Background 17
1.2. The setting: Senegal 20
1.2.1. Senegal's macroeconomic environment 20
1.2.2. Agriculture for development and poverty alleviation: a huge challenge 23
1.2.3. Overview of the dynamism of Senegalese Horticulture 24
1.3. Problem statement 28
1.4. Research objectives and questions 30
1.5. The study area 31
1.6. The methodological design 33
1.7. The relevance to policy questions 35
1.8. An outline of the thesis 36

Chapter 2: A characterization of horticultural households: gender and intra-household resource allocation. Elaborative description of data **39**

2.1. Introduction 40
2.2. A characterization of horticultural households 41
2.2.1. Social and demographic characteristics of horticultural households 41
2.2.2. Horticultural household resources and assets endowment 46
2.2.3. Gender and bargaining within the household 51
2.2.4. The horticultural household livelihood or income gender-disaggregated 53

2.3. Details on horticultural plots 57
2.3.1. Plots and managers 57
2.3.2. Horticultural crops 58
2.3.3. The horticultural plots' physical condition 59
2.3.4. An evaluation of the plot production cost 61
2.3.5. Evaluating the output of the plot 70
2.3.6. Seasonal effects: a gender comparison of the yield over crop and season 73
2.3.7. The profitability of crops across gender 75

Chapter 3: Household resource allocation, gender and economic performance: efficiency measurement 78

3.1. Introduction 79
3.2. Literature review 81
3.2.1. Economics of household resource allocation and gender 81
3.2.2. Efficiency as an indicator of performance 84
3.3. Gendering efficiency modelling 85
3.4. The empirical analysis: functional form and variables 87
3.5. The data 90
3.6. Empirical results and discussion 91
3.6.1. An estimation of unitary and gender-specific stochastic frontier production functions 91
3.6.2. Gender and the efficiency of the allocation of resources within the household 95
3.6.3. Technical efficiency across gender 101
3.6.4. Determinants of technical inefficiency across gender 104
3.7. Conclusion and policy implications 109

Appendix 3.1. 112

Chapter 4: Households profit optimization and the efficiency of labour contract choice 115

4.1. Introduction 116

4.2. A literature review on land tenancy 117

4.3. The theory 122

4.4. Household modelling and labour 124

4.5. The empirical analysis 133

4.5.1. Functional forms and variables 133

4.5.2. Endogeneity and the choice of estimator 134

4.6. Empirical results and discussion 135

4.6.1. A comparison of plot size, inputs use intensity and output across labour contract 135

4.6.2. An estimation of the production functions 138

4.6.3. Household profit optimization across plots under a sharecropping labour contact and a wage labour contract 143

4.6.4. An efficiency test of the labour contract choice based on optimum profit: the sharecropping labour contract versus the wage labour contract 149

4.6.5. An efficiency test of the labour contract choice based on optimum profit: household labour versus the sharecropping labour contract 150

4.6.6. An efficiency test of the labour contract choice based on optimum profit: household labour versus the wage labour contract 152

4.6.7. An efficiency test of inputs use based on household profit optimization across labour contract 154

4.7. Conclusion and policy implications 156

Chapter 5: Risk attitude and its effect on resource allocation 159

5.1. Introduction 160

5.2. The experimental design and procedure 163

5.3. The theoretical model 165
5.3.1. Modelling risk attitude 165
5.3.2. Modelling the effect of risk on the efficiency of choice of inputs and labour 167
5.3.3. Modelling the effect of risk on the choice of labour contract 170
5.4. The empirical model and estimation 177
5.5. The empirical results 178
5.5.1. The identification of different risks and classification by order of severity 178
5.5.2. Measurement of risk occurrence 180
5.5.3. Measurement of the perception of the output market price risk 181
5.5.4. Measurement of the risk attitude toward the output market price across gender 185
5.5.5. The effect of risk attitude on the allocative efficiency of inputs 192
5.5.6. The effects of risk attitude on the choice of labour contract 195
5.6. Conclusion and policy implications 198

Chapter 6: Conclusions and Discussion **202**

6.1. Introduction 203
6.2. Summary and discussion of the main findings 204
6.3. Policy implications 212
6.4. Main limitations and the future research agenda 214

References 217

Summary 229

Résumé (Summary in French) 235

Samenvatting (Summary in Dutch) 242

Acknowledgments 248

Citation of Sponsors 251

Curriculum Vitae 253

Training and Supervision Plan 254

List of Acronyms

GDP	Gross Domestic Product
MDG	Millennium Development Goal
DSRP-PRSP	Poverty Reduction Strategy Paper
GNI	Gross National Income (GNI)
CFA	Communauté Financière Africaine (West African currency exchange)
OLS	Ordinary Least-Squares
2SLS	Two-Stage Least-Squares
SNEEG	National Strategy for Gender Equity and Equality

List of Tables

Table 1.1: The volatility of horticultural crops' market prices in case of tomato and cabbage. 27

Table 2.1: Horticultural households' characteristics over gender 45

Table 2.2: Other wealth of the household 50

Table 2.3: The participation of women on men's plots and vice versa 51

Table 2.4: The household annual income and its composition over gender and season 56

Table 2.5: Distribution of plots over gender, zone and social status of the plot manager 58

Table 2.6: Distribution of crops across men and women plot managers in the sample. 59

Table 2.7: Gender comparison of inputs used per hectare on men's and women's plots within households. 62

Table 2.8: Time spent per plot and season by household members working on men's and women's plots over plots under household labour. 65

Table 2.9: Time spent per cropping operation by household members working on men's and women's plots under household labour. 66

Table 2.10: Labour time and wage over plots under household labour, a wage labour contract and a sharecropping labour contract. 69

Table 2.11: Output in value per plot, per hectare, and per crop on men's and women's plots. 73

Table 2.12: Comparison per crop and season of yield in quantity and in value per hectare over men's and women's plots. 75

Table 2.13: Comparison of profit per hectare across crops, gender, and labour. 76

Table 3.1: Gender comparison of the means of the variables used in the production functions. 91

Table 3.2: Maximum Likelihood estimates of the unitary and gender-specific stochastic frontier production functions for cross-sectional and panel data. 93

Table 3.3: Gender comparison of the Value of the Marginal Product of inputs within the

household. 97

Table 3.4: Gender comparison of technical efficiency scores using unitary and gender-specific stochastic frontier production functions. 102

Table 3.5: Gender comparison of technical efficiency scores by crop and by model. 104

Table 3.6: OLS estimates for the determinants of technical inefficiency, based on the unitary and gender-specific inefficiency models. 105

Table A 3.1: Estimates of the parameters of the unitary and gender-specific stochastic frontier production functions for onion. 113

Table A 3.2: Estimates of the parameters of the unitary and gender-specific stochastic frontier production functions for cabbage. 114

Table 4.1: The distribution of labour across clusters, based on plot size cropped 136

Table 4.2: A comparison of input use intensity and output across labour. 138

Table 4.3: Descriptive statistics of variables used in the plot level, crop-specific production functions estimation. 139

Table 4.4: The Two-Stage Least-Squares (2SLS) and Ordinary Least-Squares (OLS) estimation for plot level crop-specific production functions (robust clusters in households). 140

Table 4.5: The return to scale, controlling for crop and irrigation equipment 143

Table 4.6: Plots with an efficient labour contract choice 150

Table 4.7: Comparison of the optimum profit derived from a sharecropping labour contract (π_s) and household labour (π_h) for a given plot and controlling for crop, irrigation equipment, and labour. 151

Table 4.8: Descriptive statistics of the wage paid by the household to hired wage labour across plots, crops, and motor pump (fcfa/hr). 153

Table 4.9: A comparison of the optimum profit derived from a wage labour contract (π_w) and household labour (π_h) for a given plot and controlling for crop and irrigation equipment. 153

Table 4.10: The efficiency of the use of inputs based on household profit optimization across labour contract and crops. 155

Table 5.1: The identification and prioritization, by order of severity, of different risks

faced by plot managers across gender 180

Table 5.2: The chance of an occurrence of risk across gender 181

Table 5.3: The appreciation of the output market predictability by men and women plot managers 181

Table 5.4: The annoying output market price fluctuation 182

Table 5.5: Next month's predicted output price probability across gender and given the current output market price (P). 183

Table 5.6: Risk aversion scores across gender. 188

Table 5.7: The distribution of risk aversion classes across gender. 188

Table 5.8: The pairwise correlation of risk perception and risk attitude across gender. 190

Table 5.9: Risk attitude, individual and household characteristics (robust cluster in the household). 192

Table 5.10: Estimation results of the effects of the producer's risk attitude on the allocative inefficiency of inputs over gender. 194

Table 5.11: Risk aversion scores across labour contract choice 195

Table 5.12: The choice of labour contract and the producer's risk attitude: a seemingly unrelated bivariate probit estimation. 196

Table 5.13: Probit estimation results and marginal effects of producer risk attitude on choice of sharecropping contract (robust cluster in household) 198

List of Figures

Figure 1.1: The growth of Senegal's Gross Domestic Product (GDP) and the share of agriculture over time. 22
Figure 1.2: The evolution of the Senegalese vegetable production over time. 25
Figure 1.3: Map of the study area in the Niayes Zone of Senegal, West Africa. 33
Figure 2.1: Composition of men's and women's total annual income. 57
Figure 2.2: Box plots of yield and plot size over the gender of the plot manager. 70
Figure 2.3: Gender comparison of the yield evolution over years. 71
Figure 2.4: Gender comparison of horticultural crops' selling price over harvesting sequence per plot. 72
Figure 3.1: Gender comparison of the distribution of the value of the marginal product of inputs and land. 99
Figure 3.2: Kernel density estimate of the distribution of the value of the marginal product of hired wage labour on men's plots. 100
Figure 3.3: Gender comparison of the cumulative distribution of the technical efficiency scores. 103
Figure 4.1: Diagrammatic presentation of the model of labour contract choice over mechanization of the production. 122
Figure 4.2: Values of the profit ratio R0 (no supervision and the sharecropping opportunity wage equals the wage paid by the household: σ=0 and $w_o = w = w_h$), and values of the wage ratio $\frac{w_o}{w_h}$ (opportunity cost of sharecropper / wage including supervision cost) at which the profit ratio R ($\frac{\pi_S^*}{\pi_w^*}$) is equal to one for γ=0.1 and varying values of λ. 131
Figure 4.3: Distribution of the supervision rate of wage labour. 144
Figure 4.4: A comparison of the average optimum profit derived by the household from plots under a sharecropping contract and a wage labour contract and controlling for a motor pump. 146
Figure 4.5: A comparison of the average optimum profit derived by the household from plots under a sharecropping contract and a wage labour contract, and controlling for crop and motor pump. 148

Figure 4.6: An efficiency test of labour contract choice based on optimum profit and varying supervision rate or wage ratio: sharecropping labour contract versus wage labour contract. 149
Figure 5.1: The fall in profits for unit changes in relative risk aversion coefficients. 175
Figure 5.2: All crops and cabbage, observed market prices, average, minimum and maximum market prices predicted for next month, given the current prices. 184
Figure 5.3: Modified minimum and maximum prices of the risky market and modified certainty equivalent prices over gender. 186
Figure 5.4: Kernel density estimation of the distribution of risk aversion scores across gender. 189
Figure 5.5: Histogram of the distribution of risk aversion classes across gender. 190

Chapter 1.

Introduction

1.1. Background

Women play an important role in agricultural production, particularly in Africa. By managing their own farm and by providing their labour to their husband's fields, women contribute significantly to agricultural development. Women mostly accomplish several management and decision-making roles in farming practices together with their male counterparts (Samanta, 1995), but also on their own.

In Africa, and all over the world, regardless of the predominance of a gender bias in the access to resources, women present a vital and active force in the elaboration of a multitude of strategies that make farming and rural life economically viable and environmentally sustainable (Howard-Borjas and Rooij, 1996). Even across European countries, women farmers are far from playing passive roles; rather, they are major actors in the processes of transformation occurring in food and agricultural systems (Howard-Borjas and Rooij, 1996).

Throughout the world, gender issues in the development of agriculture and women's role and contribution to agriculture continue to be a great subject of debate. Despite the wide variety of literature available, the importance of agriculture to the economic development in Africa and the critical role that rural women play within this sector still remain an attractive agenda of research (Singh, 1988; Argawal, 1994; Samanta, 1995; Henderson, 1995; FAO, 1995; Howard-Borjas and Rooij, 1996; Adesina and Djato, 1996; Quisumbing *et al*., 1998; Deer and Doss, 2006; Koopman, 2009).

In Sub-Saharan African countries, in which on average 29% of the gross domestic product (GDP) is generated by agriculture (World Bank, 2007), women contribute about 60-80% (FAO, 1995) of the labour force used in the production of food destined for both household consumption and the market. However, due to customary norms, women's access and control over the resources of production are very limited. For instance, women's ownership and use of land is usually constrained by inheritance and land tenure laws[1]. In Africa, as a result of customary norms rather than religious rules, women are usually excluded from land ownership through inheritance in

[1] http://www.fao.org/Gender/en/agrib3-e.htm .

favour of men, who hold the property and hand it over to the sons within the household or to other male relatives within the extended family. Therefore, in Senegal like in most African countries, while men can inherit land from their parents, such is usually not the case for women, who get allocated just a portion of land by their husband, with a right of use rather than a right of ownership. For this reason, many African women's customary land rights are insecure; these usually depend on their marital status and can be lost after a divorce from or death of the husband (Joireman, 2008; Koopman, 2009).

Over all the continents, women own and control far less land than men do (Deere and Doss, 2006), but particularly in Africa, women rarely own land in their own right (Joireman, 2008; Koopman, 2009). However, throughout Africa, many countries like Senegal have reviewed some of their legislation related to land use and ownership rights in order to attain a better gender equity. Nevertheless, customs and a lack of information still prevent women from getting access to land, despite some improvements made on the gender equity regarding land use rights. Therefore, until now, these improvements have not been very effective.

Evidence has shown that agricultural production can be improved through equal access to production factors for men and women (Alderman *et al*., 1995; Quisumbing, 2003; Koopman, 2009). Inequality between men and women, or gender disparities, limits economic growth and favours poverty. For this reason, one of the main objectives of the Millennium Development Goal (MDG), aimed at reducing poverty and stimulating growth[2], is to promote gender equality and women's empowerment. In Senegal, for instance, a National Strategy for Gender Equity and Equality (SNEEG) has been elaborated in order to promote gender equality. The SNEEG will permit the development of tools and methodologies of gender analysis, the implementation of programmes that aim to reinforce the capacity of actors in terms of the promotion of gender equity and equality, the promotion of the elaboration of gender-sensitive budgets for the different economic sectors, the reinforcement of the decentralisation of funds for the economic promotion and support of women's activities, and the reinforcement of women's leadership capacity (DSRP 2, 2006).

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[2] The World Bank : http://go.worldbank.org/NMIS5MXCH0 .

Yet, it still remains a challenge to improve women's agricultural performance by improving their access to land, to inputs such as seeds, fertilizers and pesticides, to credit, to extension services, and to better technologies, like labour-saving technologies and improved irrigation equipment. Women can do much better if their gender-specific constraints related to access to land and technology are addressed, and if they can enjoy the right and the economic incentives to farm their own plots (Koopman, 2009). Women's specific needs and priorities are hardly ever taken into account by researchers when designing agricultural technologies. Many agricultural development programmes did not achieve the expected impacts because they were mainly oriented towards the male household heads, implicitly assuming that the effects will be distributed over other household members. As mentioned in The World Development Report 2008, many economic development policies continue to wrongly take for granted that farmers are men. The key importance of women in the agricultural sector in many parts of the world, and particularly in agriculture-based countries in Africa, calls for urgent attention for a more gender-sensitive policy, allowing for gender-specific production constraints and priorities.

Similarly, in many economic theories, the "rational economic man" has been the main agent targeted. However, gender-asymmetric identities, gender difference in terms of social position, roles, preferences, basic and strategic needs, endowment assets, access to resources, allocation of time and income, performance, risk attitude et cetera widely justify the need for a greater awareness of gender issues in economic analysis.

Particularly at the household level, an economic analysis based on a gender perspective is the way to shed light on the differentiation between men and women as economic agents who behave differently and specifically, in terms of their choice of labour, non-labour inputs and risk attitude. Regarding access to resources within the household, gender inequality arises with an array of social and economic implications. A better understanding of these gender issues requires moving beyond unitary models of the household and into the household itself (Akram-Lodhi, 1997).

Farm households involved in the horticultural supply chain in Senegal, in West Africa, provide a convenient context to illuminate such gender issues in agricultural development. Usually, in Senegal, within horticultural households, both men and women or husbands and wives manage their separate horticultural plots. Next to household labour, men and women plot managers hire labour, based on a sharecropping contract or a wage contract. The development of horticulture is strongly linked to the economic performance of both men and women plot managers within these households. Economic performance can be captured through the analysis of the efficiency of the allocation of productive resources between men and women plot managers and the efficiency of the use of these resources by them. Equally, economic performance can be scrutinized by analysing the efficiency of the labour contract choice made by men and women plot managers. Men and women are heads of the horticultural households or managers of separate plots within the households; in this role, they may show different preferences or behaviour, notably towards risks. Such differences may have an effect on their economic performance and choice of labour contract; thus, they need to be measured and accounted for. By providing theoretical and empirical evidence on these issues, this thesis intends to make a scientific contribution to the gender and economics literature. The results show to what extent female heads of horticultural households differ from male heads, and wives from husbands, in economic performance and in risk preferences. The specific social, cultural, economic, and institutional context that men and women face is accounted for.

1.2. The setting: Senegal

1.2.1. Senegal’s macroeconomic environment

In developing economies, such as African countries, economic development is strongly linked to the agricultural sector. In most of them, more than half of the population is rural and has agriculture as its major economic activity and source of food and income. Paradoxically, for most African countries, the local food crop production remains far insufficient to cover the national staple food needs. These countries face chronic food insecurity and poverty. Senegal can be seen as a typical example of such developing Sub-Saharan African countries.

An analysis of Senegal’s economic evolution shows that the annual economic growth rate was about 2.7% between 1960 and 1993, while its demographic growth rate was 2.9% (DSRP 2, 2006). This difficult economic situation was one of the reasons for a structural adjustment programme that included policy reforms devaluating the parity of the CFA franc. This change of parity and the other policy reforms provided an impulse to the economy. It again started to grow better, with a sustained increase of the gross domestic product (GDP) of about 5% between 1994 and 2002, in a context of relative control of inflation and a decrease of public deficit (DSRP 2, 2006). The increase of the economic growth is imputable to the regaining of competitiveness of some export products, such as fish, horticultural products, peanuts, and phosphate.

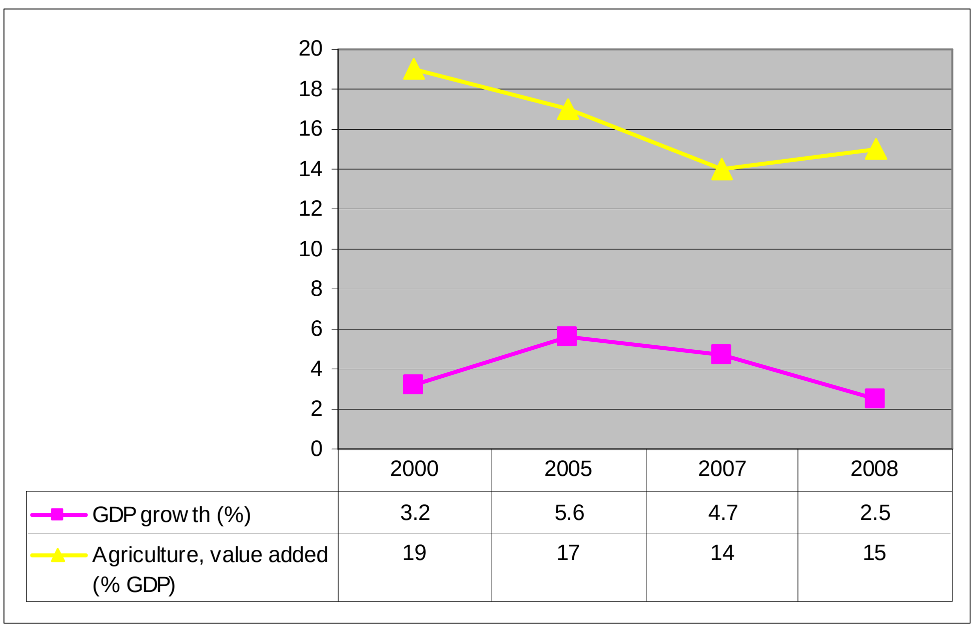
In 2003, the first Poverty Reduction Strategy Paper (PRSP 1 – DSRP 1) was elaborated, covering the 2003-2005 period. The PRSP can be considered as the document of economic and social policy for economic growth and poverty reduction and as the reference for government interventions as well as development partners, civil society, the private sector, and local communities. The evaluation of PRSP 1 showed satisfactory results. In fact, between 2003 and 2005, the economic growth maintained a positive trend, with an annual average rate of more than 5% (figure 1.1) within a context of improvement of the management of public finance, a controlled inflation rate of less than 2%, and the consolidation of other macroeconomic aggregates (DSRP 2, 2006). The growth of the agricultural sector was 13% in 2005, due to the improvement of horticultural production and other agricultural programmes (DSRP 2, 2006). Between 1995 and 2005, Senegal achieved one of the best economic performances in Sub-Saharan Africa (World Bank, 2009)[3]. Nevertheless, the growth of the GDP was not enough to create sufficient employment, to significantly improve the welfare of households, or to reduce poverty.

For this reason, a second Poverty Reduction Strategy Paper (PRSP 2 - DSR 2) is being elaborated, covering the 2006-2010 period, to halve poverty in 2015 and to realize the Millennium Development Goal (MDG). The objective of economic growth is to reach a rate of 7 to 8% per year. To this end, the government has elaborated a Strategy of Accelerated Growth (SCA), to create the conditions for new gains of productivity. According to this plan, the primary sector should grow by 11% per year, influenced mainly by crop-growing, which should increase by 13%. This agricultural growth should be driven by the implementation of agricultural programmes aiming at a sustainable development, food security, an improvement of the revenue of the rural population, poverty alleviation, and protection of the environment (DSRP 2, 2006).

However, from 2006 to 2008, a series of shocks hit the Senegalese economy, which prevented it from achieving the projected economic growth rate and from meeting the objectives of the MDG.

[3] World Bank, 2009: http://go.worldbank.org/PO6JPCB5P0 .

Escalating oil and food prices in 2007 troubled the economy by pushing up inflation, from 0.5% in 2003-2005 to 4% in 2006 and 6% in 2007, and by widening the external current account deficit (World Bank, 2009). As Senegal imports 100% of its consumption in oil and wheat and 80% of its consumption in rice, it is heavily affected by the increasing oil and food prices. To these external shocks were added other, internal shocks. The economic growth was dampened by the deficit in rainfall in 2006 and 2007, which caused a fall of about 15% of agricultural production, and the crisis, which affected the phosphate mining and phosphoric acid production firm (Industries Chimiques du Senegal –ICS), one of the largest Senegalese exporting firms (World Bank, 2009). In 2008, the GDP growth was estimated at 2.5% and the inflation rate at 6%. Because of a favourable rainfall in 2008, agriculture started to grow again, but the industrial production is still declining. Graph 1.1 shows the evolution of the GDP over time, using data from the World Development Indicators database (World Bank, 2009).



Source of data: World Development Indicators database, April 2009. The World Bank.

Figure 1.1: The growth of Senegal's Gross Domestic Product (GDP) and the share of agriculture over time.

1.2.2. Agriculture for development and poverty alleviation: a huge challenge

In Senegal, like in other Sub-Saharan African countries, agriculture remains one of the most important sectors of the economy. About 60% of the economically active population are working in agriculture (DSRP 2, 2006). Agriculture continues to be the lever to activate for an equitable economic development and for poverty reduction. However, its contribution to the formation of the GDP is still relatively low and variable: from one year to another about 15 to 20% (figure 1.1). This implies that 60% of the Senegalese labour force contributes only up to 15% to the GDP while in 2008, for instance, the other 40% of the national labour force, involved in the industry and services, contributed up to 23% and 62% to the GDP, respectively (World Bank, 2009). Consequently, in Senegal, like in other developing economies, the gap between the share of agriculture in the GDP and the share of agriculture in the labour force is persistently large and challenging.

Moreover, with a Gross National Income (GNI) per capita of 840 US$ in 2006, Senegal remains a poor country (World Bank, 2009). The incidence of poverty is still high, despite the sharp decrease observed between 1994 and 2005. The share of the national population living below the poverty threshold fell from 68% in 1994 to 57% in 2002 and 51% in 2005 (DSRP 2, 2006; World Bank, 2009). The incidence of poverty is higher in rural areas, where in 2002, 65.2% of the individuals and 57.5% of the households were living below the poverty line (DSRP 2, 2006). Consequently, poverty affects the population involved in agriculture more.

In such a context, getting agriculture to move forward is crucial. Agriculture must be the leading sector for the attainment of overall growth, poverty alleviation, and a reduction of income disparities. While the growth of non-agricultural sectors has accelerated, poverty persists, which shows the difficulty of redistributing the income generated. This suggests that only a GDP growth driven by agriculture can drive out poverty. A strong agricultural growth is required to foster Senegal’s overall economic growth and to overcome poverty. There is evidence that agriculture is more powerful when it comes to poverty reduction than other sectors in agriculture-based economies are. Actually, cross-country econometric evidence has shown that, in terms of welfare gains, the poor benefit more from a GDP growth in agriculture than from GDP originating from the rest of the economy (World Bank, 2007). Moreover, there is evidence that a GDP growth generated in agriculture is at least twice as effective in reducing poverty as growth generated by other sectors is (World Bank, 2007).

However, agriculture for development and as the main pathway out of poverty can be achieved by improving the economic performance of smallholder farmers and particularly their efficiency in the use of productive resources. In Senegal, despite the augmentation of the resources allocated to agriculture with an annual increase of about 15% of the investment budget (DSRP 2, 2006), the economic performance is still too inconsistent to boost agricultural growth, to stimulate overall economic growth, and to alleviate poverty significantly. In such a context, there is a need to have more insight into the economic performance of the producers and the reasons behind it, in order to figure out ways of improvement. This is one of the motivations of this thesis, which investigates the economic performance of households involved in horticultural production.

1.2.3. Overview of the dynamism of Senegalese horticulture

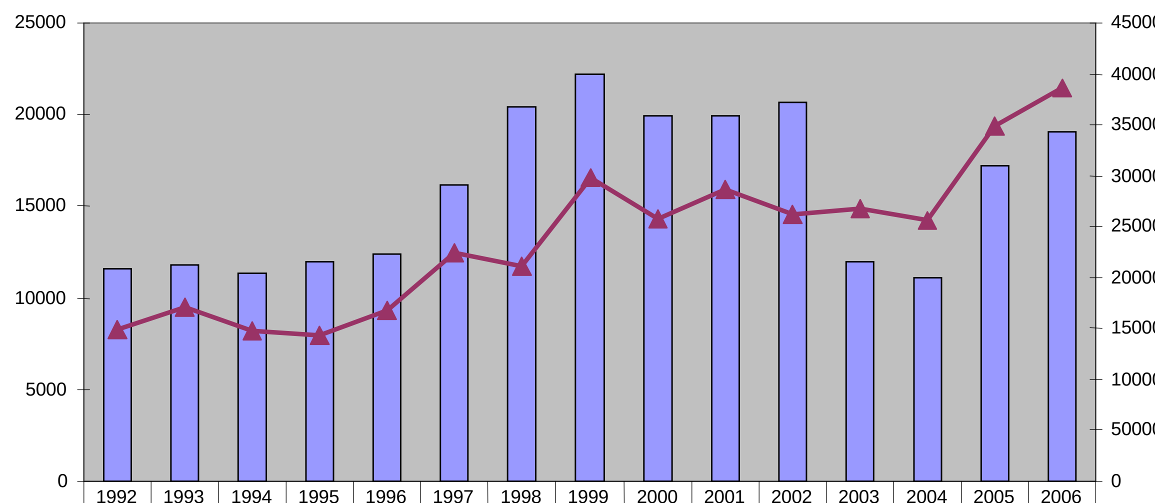
In Senegal, over the last decades and since the devaluation of the CFA in 1994, the horticultural subsector has constituted an important element of agriculture. It contributes to food security, to the diversification and increase of agricultural exports, and to the creation of employment. In addition to the farm households, horticulture attracts many national economic actors interested in the agro-business, and even foreign export-oriented firms. With the decline of traditional exports, such as groundnuts and fish, horticulture remains one of the subsectors providing the largest economic growth.

In Senegal, horticultural crops (vegetables, fruits and ornamental crops) are the third important crops, in terms of tonnage as well as in value, after cereals and groundnut. Specifically, the production of vegetables has recorded a net increase during the last decades. Production rose from about 150,000 tons in 1992 to 386,200 tons in 2006 (Direction Horticulture, 2007). This is equivalent to a growth rate of 157% over fifteen years. In 2003-2004, the vegetable production decreased due to the invasion of locusts, and the partial or total abandonment by some horticultural producers of a number of sites because of problems linked to the cost of water[4].

[4] Producers who were using drinkable water provided by the water corporation for irrigation, could not pay their water bill and were constrained to reduce or cease their horticultural production activities.

From 2005 to 2006, the production increased considerably, with a growth rate of 10%, as can be seen in graph 1.2.

The area cropped in horticulture rose from 11,600 ha in 1992 to 20,690 ha in 2002, which corresponds to a growth of 78% within 10 years. This growth is equal to the production growth, which means a proportionality of evolution of area and production. However, in 2003 and 2004, a great decrease of the cropped area was observed for the reasons underlined above, before they starting to grow again from 2005 on. As can be read from graph 1.2, from 2003 to 2006, the production increased less than the area. While the production rose by 44%, the area increased by 59%, showing a decrease in productivity.



	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
area (ha)	11608	11848	11322	12010	12392	16136	20404	22201	19918	19918	20692	11958	11054	17187	19041
production (t)	149738	170651	147375	143704	167390	223675	211045	298726	257213	286740	261695	267579	255801	348046	386210

Figure 1.2: The evolution of the Senegalese vegetable production over time (Source: data from the National Direction of Horticulture).

The dominant crops of the Senegalese vegetable production are tomato with 46% of the volume produced, onion with 21%, sweet potato with 10%, and cabbage with 8%. Potato, carrot, turnip, eggplant, green bean, cassava and hot pepper represent the second important vegetables produced in Senegal. On the other hand, vegetables such as cucumber, squash, zucchini squash, asparagus, and lettuce, as well as diverse aromatic and spicy vegetables such as green pepper, sorrel, mint, parsley, and so on, constitute the other crops grown. Thus, the Senegalese horticultural production really is diversified enough with more than twenty-five vegetable species (Direction Horticulture, 2007).

Due to the commitment of the economic operators of the agro-business, their organization in professional associations, and the effects of the projects and programmes promoting agricultural exports, the volumes of vegetables and fruits exported by Senegal have increased from 6,175 tons in 1995 to 11,125 tons in 2002 (Projet de Promotion des Exportations Agricoles, 2004) and 16,000 tons in 2005 (Maertens, 2008). This corresponds to an absolute decennial growth rate of 159%. Green bean (42% of the exported volume), tomato (23%) and mango (16%) are the chief horticultural products exported. With more than ten billion CFA francs as revenues, vegetables and fruits have become the second important product exported after fishing (Projet de Promotion des Exportations Agricoles, 2004). The horticultural products are exported mainly to France (40% of the exported volume), the Netherlands (35%), Belgium (16%), and the neighbouring countries (Maertens, 2008), like Mauritania, Gambia, Guinea, and Mali. After Morocco, Egypt, and Kenya, Senegal is the fourth African supplier of green beans to the European Union (Maertens, 2008). In addition to the farm household specialized in horticultural production, agro-business firms and exporters have also contributed a lot to the growth of the horticultural exports. There have been efforts to better meet the stringent quality standard requirements of the international markets.

However, despite these positive results, the national demand for horticultural products still remains strongly dependent on the importation of vegetables, estimated annually at 30,000 tons, which is equivalent to three billion CFA francs (Direction Horticulture, 2003). Onion constitutes 50% of the annual amount of horticultural products imported, and potato 40%. Thus, the two crops represent 90% of the total annual horticultural imports and cost 2.6 billion CFA francs. These imports come almost exclusively from the Netherlands, which accounts for 99% of the onion and 95% of the potato (GEOMAR International, 2004). However, these imports put the national horticultural production into hard competition. The main complaint of the horticultural producers is the imperfections noticed in the regulation of the imports of onion, which overlap with the commercialisation of their production. However, over the last years, to satisfy producers' complaints while protecting consumers' interests, too, the government has taken some measures to suspend the imports of onion during the period of the commercialisation of the national production, in order to avoid the oversaturation of the market and the fall of the price.

Overall, the high volatility of the horticultural crops' market prices is one of the major risks that men and women producers face. When producing, men and women cannot reliably predict the price at which they will sell their crop. The market price fluctuates a lot from one month to another (table 1.1) and even from day to day. This high market price volatility impacts upon the horticultural revenue of the farm households. Even if the yield achieved per hectare is high, if the output market price is low, the revenue derived from the production will be low, too. Moreover, producers choose the amount of labour and non-labour inputs given the uncertainty of the output market price. Consequently, the way in which horticultural producers behave toward the output market price risk may influence their decision-making with regard to the choice of inputs and may affect their economic performance. Therefore, the attitude of male and female horticultural producers toward the output market price is an important issue to take into account while investigating their economic performance. For this reason, men's and women's behaviour toward the output market price risk and its implications for their economic performance are of particular interest in this thesis.

Table 1.1: The volatility of horticultural crops' market prices in case of tomato and cabbage.

Period	Crops' market prices (FCFA/kg)[5]	
	Cabbage	Tomato
September 2006	192	175
October 2006	237	162
November 2006	264	229
December 2006	355	633
January 2007	323	580

Source: my own survey over 2006-2007 in the Niayes Zone.

[5] 1 USD=485 FCFA; 1 Euro = 656 FCFA

1.3. Problem statement

In large parts of Sub-Saharan Africa, agricultural productivity is very low due to insufficient and erratic rainfall, problems of water control and management, a low level of soil fertility, a lack of equipment and financial resources required for purchasing appropriate inputs, the rural exodus, et cetera. The potential for economic development is strongly limited by environmental, agro-technical, socio-economic, and institutional constraints (Sissoko, 1998). In addition, the underinvestment by most governments and international donors (De Janvry, 2009), the poor infrastructures and limited markets access (Kuyvenhoven *et al.*, 2004; World Bank, 2007) have all contributed to agricultural and economic stagnation.

However, agriculture still remains “a vital development tool for achieving the Millennium Development Goal that calls for halving by 2015 the share of people suffering from extreme poverty and hunger” as mentioned by Robert B. Zoellick, World Bank President (World Bank, 2007). Consequently, in Sub-Saharan Africa, it has become more of a challenge than ever to boost up agriculture in order to stimulate economic growth, improve food security, and alleviate poverty. Evidence has shown that in Africa, public investment in agriculture provides a high rate of return because of its growth and poverty reduction effects (Adesina, 2009).

Over the world, and particularly in Africa, women’s involvement in agricultural production is broadening and deepening (World Bank, 2007). An agriculture-led development in Sub-Saharan Africa requires community-driven approaches, with women, who account for the majority of the producers in the region, playing a leading role (World Bank, 2007). Much more attention must be paid to the gender dimension of agriculture.

Moreover, in the current context of high and volatile world food prices, which affects Africa much more than other developing regions of the world (Adesina, 2009), a sharp increase of agricultural productivity of both staple and high added-value crops is more than ever necessary. As a result of the emergence of the monetary economy and the requirement for the rural population to have money in order to satisfy their vital needs, cash crops have gained importance over food crops. For this reason, current alternative strategies focus on growing products with a higher net added value per hectare, like horticultural products such as vegetables, flower bulbs

(Bremmer, 2004), and fruits. Particularly in developing countries, because of market opportunities at the national and international level, horticultural products saw a rapid agricultural market growth, shown by an increase of the production by 3.6% a year for fruits and 5.5 % for vegetables over the 1980-2004 period (World Bank, 2007). This horticultural revolution, driven by the domestic and global market, contributes a lot to the growth of agriculture in developing economies. Compared to cereal production, horticulture is twice as labour-intensive and rises by tenfold the returns on land (World Bank, 2007). Accordingly, horticulture is a real source of income and employment generation.

Particularly in Senegal, over the last decades, the horticultural subsector constituted without any doubt a vital element of agriculture, due to its contribution to the satisfaction of food needs, the foreign exchange generated through exports, and the importance and diversity of the economic actors involved. Horticulture remains one of the subsectors providing the largest economic growth and constituting a great hope for Senegal's agricultural development. However, despite the dynamism observed and shown by the increase of the horticultural production and the exports, the national production is still far from being sufficient to cover the national demand. Senegal is strongly dependent on imports of horticultural products, which contribute to weighing down the balance of payment.

To increase horticultural growth by scaling up the productivity and the land cropped, to reduce the import bill, to export more horticultural products, and to be more competitive are some of Senegal's major objectives. Given the relatively high horticultural potential of the country and the domestic, regional, and global market opportunities, these objectives do not seem to be unrealistic. However, the performance of the different actors involved in the horticultural supply chain is a concern. Accordingly, it remains a challenge to gain more knowledge about the level of economic performance of the producers and especially the farm households, taking into account the technical, economic, institutional, social, and environmental constraints they face. These constraints may vary across households and across the gender of the plot managers within households. While some households can afford some modern and adapted equipment, such as motor pumps, which reduce the labour needs, other households cannot, and subsequently, have to rely on family labour and hired labour. Similarly, while male heads of household or managers of plots have enough land and access to credit, female ones have limited access to these factors.

Moreover, the way in which horticultural producers behave toward the output market price risk, may have implications for their economic performance, particularly for their efficiency and their choice of labour contract. Such issues are of particular interest in this research thesis.

1.4. Research objectives and questions

This research is a part of the African Women Leaders in Agriculture and Environment (AWLAE) programme, which aims to examine and enhance gender roles in the food production systems in Africa at the level of the household[i].

The goal of this research is to contribute to improving the income of horticultural households in Senegal through the development of horticultural production, to attain more economic growth, food security, and poverty alleviation. Specifically, this research aims to acquire more insight into the economic performance of horticultural households, by using efficiency as key indicator of performance and through two main approaches or perspectives:

1. firstly, a gender perspective based on a differentiation within farm households (male and female managers of plots) and between farm households (female-headed and male-headed);
2. secondly, a labour perspective founded on the demarcation between production systems based on household labour and hired labour, based either on sharecropping contracts or wage contracts.

Moreover, this research aims at theoretically and empirically investigating men’s and women’s behaviour towards the output market price risk and its implications for their economic performance and choice of labour contract.

To achieve these objectives, the main economic issue addressed is the question of economic performance, and especially of efficiency. This efficiency is assessed in a specific social, economic, and cultural context in which polygamy occurs and husband and wives usually manage their plots separately. Moreover, it is assessed in a context where household labour is generally the dominant input and where the labour market offers two common forms of contract, based on wage and sharecropping. The labour market also shows high transaction costs linked to the supervision of labour. Specifically, this research has the ambition to find answers to four main research questions:

1. Is the household's allocation of resources over men and women efficient?
2. Are contracts with hired workers, either as wage labourers or as sharecroppers, efficient for household profit optimization?
3. Do risk preferences differ between husband and wives, and between male and female heads of the household?
4. If so, how are they related to individual characteristics, and what are the effects on their performance and choice of labour contracts?

A fifth question follows from the findings and is related to the conclusions regarding policy:

5. How to improve the economic performance of men and women involved in horticultural production? What is the best way to reduce the likely gap in economic performance linked to gender, scale and labour contract? What can policy do to influence or accommodate male and female producers' risk behaviour towards the output market price and its repercussions on their performance?

1.5. The study area

We have carried out the research in Senegal, in the Niayes Zone, which is the band surrounded by the Atlantic Ocean and located along the axis Dakar – Saint-Louis Regions (see the map in figure 1.3). We have chosen the Niayes Zone as research area because it constitutes, together with the Senegal River Valley, an agro-ecological zone of Senegal that is excellently suited to horticulture. The Niayes Zone is still the leading horticultural production zone and is the best example in terms of an integrated use of favourable factors of production and marketing (Matsumoto-Izadifar, 2008). About 80% of the national horticultural production comes from the Niayes Zone. This horticultural vocation is conferred by numerous potentialities related to favourable climatic, soil and hydraulic conditions as well as by the proximity to the urban markets. In fact, its tropical and sunny climate is marked by a great maritime influence. The average temperatures, ranging from 22^{o}C in January and 31^{o}C in October, are favourable to horticultural production. They are relatively fresh compared to the temperatures observed in the country's interior, a relatively consistent humidity varying between 58% in December and 83% in August, and a rainfall varying from the North to the South from 300 to 500 mm per year.

The relief of the Niayes zone is modelled with a succession of sandy dunes and depressions. The soil, characterized by a dominant sandy texture, is very favourable to horticultural crops. The hydrograph is characterized by the proximity of the water table in most of the areas and the presence of lakes, temporary basins and ponds. With its potentialities, the Niayes zone is a veritable pivot of development for horticulture. However, in some places, particularly in the south zone of Niayes, the availability of water is a limiting factor. While in the centre zone of Niayes, the water table can be reached even with a non-cemented, traditional well at a depth of one meter, in the south zone of Niayes, near Dakar, in some places, the water table is so deep that the source of water used for irrigation is that of the water corporation. It is water filtered for drinking, and for this reason it is expensive and its provision is irregular. The water constraint has caused some producers to cease their horticultural production completely, while others have only partially done so, by reducing their cropped area.

In terms of demography, in the last national agricultural census done in 1998, the Niayes Zone accounted for 35.000 rural households, distributed over 20.000 family residences and more than 750 villages (RNA, 1999).

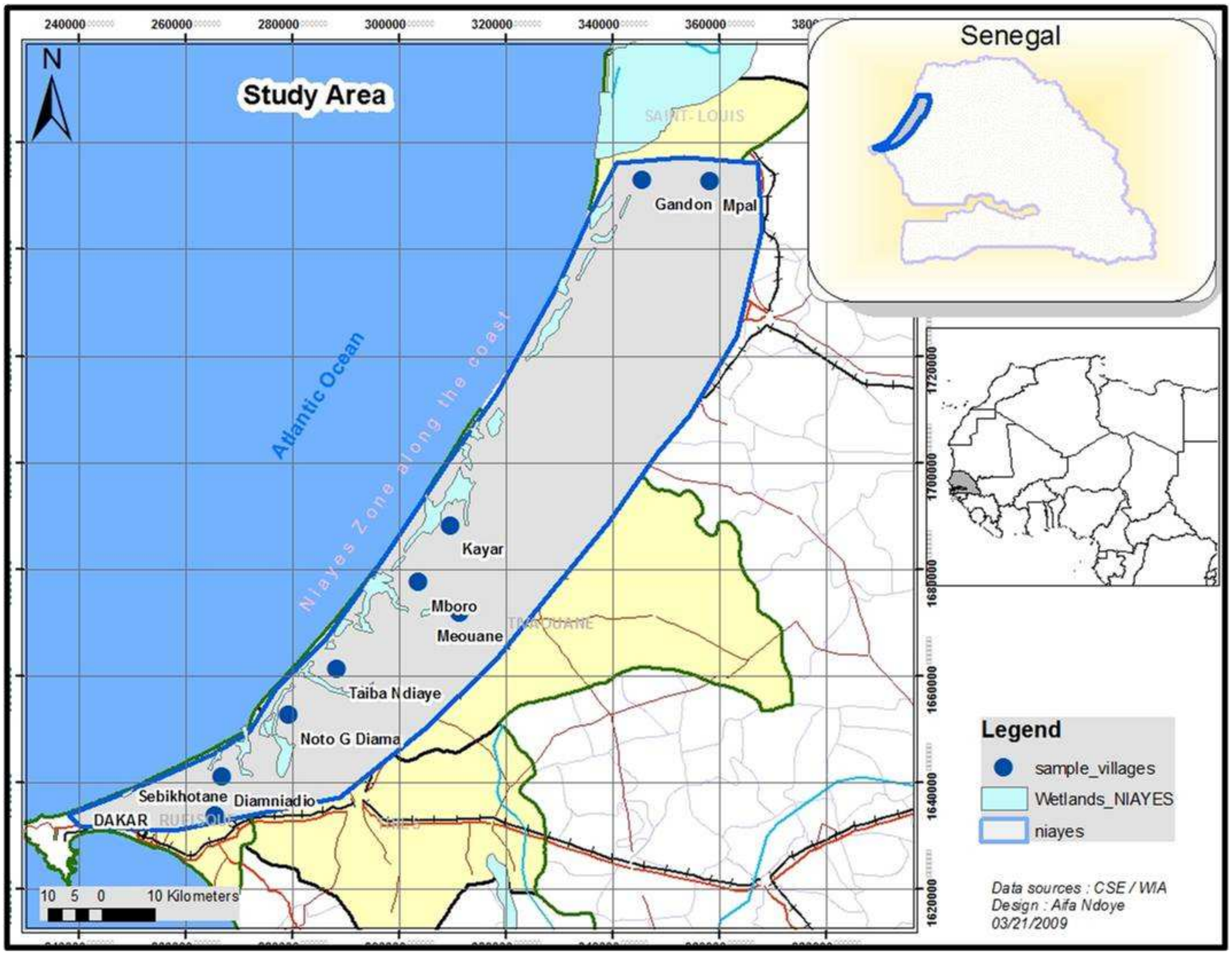


Figure 1.3: Map of the study area in the Niayes Zone of Senegal, West Africa.

1.6. The methodological design

The research strategy

This research uses a quantitative focus, based on a large-scale survey of horticultural households. A stratified and random sample of 203 horticultural households was selected in 30 villages, distributed over the three main subzones of the study area, the Niayes Zone. The stratification was based on subzone, villages, gender, and labour used. Based on a list of the villages classified by zone and district, a sample of 30 villages was selected randomly. In each village, 6-7 horticultural households were sampled randomly but also in a stratified manner, in order to include horticultural households headed by both men and women and including those using household labour, wage labour, and sharecropping labour. In each village, household heads were listed and classified into different groups, based on gender and type of labour used in the village. As much as possible, we randomly selected the same number of households (by lottery) in each group. In each horticultural household, we surveyed all the male and female managers of horticultural plots. In this way, we surveyed a total of 422 horticultural plots in 203 households, of which 308 are managed by men and 114 are managed by women. On these fields, men and women produce the same horticultural crops.

The research material

In addition to direct observations and semi-structured interviews, formal structured questionnaires were designed and used to collect the required labour and gender-disaggregated field data at household level and at plot level, related to:

- the major characteristics of horticultural households, such as their socio-demographic composition, migratory movement, labour availability, resources or assets (land and its allocation to different members, and crops, livestock, agricultural equipment and so on), and organisation;
- the quantities and prices of different factors of production, inputs and outputs at plot level;
- the access to information, markets and other institutions (credit, saving, insurance, extension services, professional organisations), opportunities, constraints and strategies;
- the determinants of preferences, including the risk attitude, control of assets according to gender (land ownership, the allocation of labour, time and inputs, control of other assets and income), and production planning.

In addition to the survey, we implemented a new experimental measurement of the risk attitude of men and women plot managers within the farm household. The experimental game is inspired by methods used by Binswanger (1980), Wik *et al.* (2004), and Senkondo (2000), but it is based on a game with a set of output prices as payoff.

The research methods

The research methods are based on various theoretical and empirical models and econometric estimates allowing for gender. Each specific model is considered to be suitable for answering a specific research question. Accordingly, in order to answer the first research question, unitary and gender-specific stochastic frontier production functions are estimated. From these models are derived the technical efficiency scores, the inefficiency component and its relationship with other individual and socio-economic household characteristics, and the allocative efficiency.

To address the second research question, a theoretical and empirical model based on household profit optimization is used, to test the efficiency of the choice between household labour, a sharecropping labour contract and a wage labour contract, while controlling for the irrigation equipment used on the plot.

For the third research question, we have used a model based on producer-expected utility, which is in concordance with the experimental game implemented, to determine men's and women's risk attitude. Theoretical and empirical models based on the maximization of the expected utility of profit, given the uncertainty of the output market price, are designed to examine the effects of risk attitude on economic performance and choice of labour contract, an examination that helps to reply to the fourth research question.

The empirical evidence of each model tested leads to recommendations to policy makers and thus contributes to tackle the fifth research question. The different theoretical and empirical models are presented in detail in each chapter.

1.7. The relevance to policy questions

This research sheds light on the level of economic performance of horticultural households, taking into consideration gender, type of labour contract and risk attitude. Such information is useful for producers, agro-business operators, agricultural research, extension services, NGOs, donors, and particularly for policy decision makers aiming at the enhancement of the horticultural subsector. Especially in the current context of world food crisis, there is a need, more than ever, to examine the economic performance of the agricultural producers, in order to confront the challenges ahead. This research provides policy decision makers with suitable strategies, which will lead to an improvement of the economic performance of horticultural households and is based on a gender perspective. Future horticultural projects, programmes and policies will be designed better and more accurately when based on the results, information and recommendations provided by this research.

1.8. An outline of this thesis

This study is structured into the six following chapters:

- Chapter 1, which is the present one, consists of the general introduction outlining the background, biophysical, social, and macroeconomic context of this research, the problem statement, the purpose and the research questions, the methodology, the policy relevance, and the different chapters.
- Chapter 2 will describe the characteristics of the horticultural households from a gender standpoint. In doing so, this chapter will provide enough background information about the environment of the study at the micro level.
- Chapter 3 will shed light on the economic performance of men and women measured in terms of efficiency. Thus, in addition to the technical efficiency and its determinants, this chapter will examine the optimum efficiency of the allocation of resources over husband and wives managers of separate plots within a household. Accordingly, this chapter will address the first research question.
- Chapter 4 will focus on the comparative analysis of household profit optimization across plots under household labour, a sharecropping labour contact and a wage labour contract. Next, the chapter will provide evidence on the efficiency of labour contract choice and the inputs used at plot level. In doing so, the chapter will seek to answer the second research question.
- Chapter 5 will examine the difference in risk preferences between husband and wives, and between male and female heads of the household. Also, it will investigate the effects of risk attitude on the economic performance and on the decisions made regarding the choice of labour contracts. Consequently, this chapter will deal with the third and fourth research questions.

- Chapter 6, finally, after answering the fifth research question, will come up with the recommendations. It will examine suitable strategies that will lead to an improvement of the economic performance of horticultural households by means of a gender perspective. This chapter will also discuss the policy implications, the conclusion, and the outlook for future research.

[i] This research thesis is one of the twenty PhD theses managed by the African Women Leaders in Agriculture and Environment (AWLAE) and Winrock International (WI), in partnership with Wageningen University and Research Centre (WUR) and funded by the Netherlands Directorate-General for International Cooperation (DGIS), aiming at contributing to gender research in Sub-Saharan Africa in a context of HIV/AIDS prevalence.

There is hardly a requirement to repeat that the HIV/AIDS pandemic is one of the most dangerous diseases affecting the world, devastating African societies and economies in particular. The number of persons living with HIV/AIDS, the number of deaths, widows and orphans due to this disease, and the prevalence rate are very high. In 2007, the number of deaths due to AIDS was estimated at 2.1 million worldwide, of which 76% occurred in Sub-Saharan Africa (UNAIDS/WHO, 2007). Compared to the past two years, some declines are observed, which according to UNAIDS/WHO (2007) are partly attributable to the scaling up of antiretroviral treatment services. “AIDS remains a leading cause of mortality worldwide and the primary cause of death in sub-Saharan Africa, illustrating the tremendous, long-term challenge that lies ahead for provision of treatment services, with the hugely disproportionate impact on sub-Saharan Africa.” (UNAIDS/WHO, 2007). The social, economic and political implications of this disease are numerous and various. In this situation, decisive actions are required to fight against this disease and its heavy and negative effects.

While the implications of the AIDS crisis are devastating Sub-Saharan Africa, some countries like Senegal have made progress fighting the pandemic (PUTZEL, 2003). This progress results from a strong commitment by the government, which has in an early stage adopted a multi-sectored approach based on the mobilization and involvement of key partnerships, such as between different ministries, influential religious organizations, and non-governmental actors, such as NGOs, associations, the private sector, and so forth. The result of these combined efforts was a low HIV/AIDS national prevalence rate of 1% in 2007 (UNAIDS/WHO/UNICEF, 2008). Because of this low prevalence rate, it is difficult to find in the studied sample a representative number of horticultural households affected by this disease and to find a correlation with the socio-economic data. For this reason, this study does not deal with HIV/AIDS. However, we recommend that, despite its positive results, Senegal must not rest on its laurels; it needs to keep up its efforts to better inform the population, whether urban or rural, about the HIV/AIDS pandemic. This remains the key strategy to safeguard its relative progress.

Chapter 2.

A characterization of horticultural households: Gender and intra-household resource allocation. Elaborative description of data

2.1. Introduction

For any study centred on the household, it is greatly important to get insight into the household itself to find out its main social, demographic and economic characteristics, before proceeding to any other type of analysis. For this reason, this chapter gives a characterization of horticultural households located in the Niayes Zone of Senegal. This characterization will be given from a gender standpoint, in other words, using a disaggregation into men and women of all the data collected from a survey of 203 horticultural households.

A horticultural household is defined as a group of people or a family-based community composed of a head (usually a man and sometimes a woman), wives and children as well as extended relatives, living together in a unit of residence, sharing their meals, cultivating mostly horticultural crops on their land jointly or separately, and/or doing other work with as overall objective the welfare and secured livelihood of its members.

Accordingly, this chapter first focuses on:

i. the social and demographic characteristics of horticultural households in section 2.2.1;
ii. the economic characteristics with a particular focus on horticultural household resource and assets endowment in section 2.2.2;
iii. gender and bargaining within the horticultural household in section 2.2.3;
iv. and finally, estimating the horticultural household income in section 2.2.4.

Secondly, after this global characterization of horticultural households, this chapter intends to shed light on the gender distribution of household resources between husband and wives or, more globally, men and women managers of separate plots within the household. Getting inside the horticultural household, this second part of the chapter identifies the horticultural plots and crops sampled (sections 2.3.1 and 2.3.2), describes the issues linked to the physical conditions of men and women’s plots (section 2.3.3). This is followed by an evaluation of the inputs used by men and women plot managers (section 2.3.4), the output (section 2.3.5), the seasonal effects (section 2.3.6), and the profitability.

Thus, this chapter gives an elaborate description of the data, providing enough background of the horticultural households for the analysis of their economic performance.

2.2. A characterization of horticultural households

2.2.1. Social and demographic characteristics of horticultural households

Horticultural households' headship, gender and age

A total of 203 horticultural households were surveyed in the Niayes Zone. Among them, 190 are headed by men and only 13 by women (6.4%). These female heads of household are mainly widows (10 out of 13) with often young children, or married women with a husband permanently migrated inside the country, particularly to Dakar, the capital city of Senegal, or to foreign countries like Europe. The widowed women become head of household, managing all the resources; they are responsible for the family needs. The women whose husbands have migrated permanently, coming back home for only a short time, are in a similar position.

In terms of age, households heads show a large diversity. The youngest household head is 21 years old and the oldest one is 84. This denotes that some heads are very young and some others rather old. On average, the age of a household head is about 51 years. Most of the household heads are in their forties and sixties. There is no major age difference between male and female heads of horticultural households.

Household kinship composition and size

In terms of kinship, a horticultural household is commonly composed of a husband who is the head, wives, sons, daughters, and other extended relatives. The marital status of horticultural household heads shows that polygamy is widely practised. The number of wives ranges from 1 to 4. Among the 190 male heads of household, 43% are monogamous and 57% are polygamous. In greater detail, 35% of the heads of household have 2 wives, 18% have 3 wives, and 4% have 4 wives. The wives share the same house.

Obviously, the polygamous status of most horticultural household heads impacts on the number of their children. Household offspring varies from 0 to 21 persons, with an average of 6. It is important to note that only the children who are living with the household head or who have emigrated but still belong to the household are accounted for. The children who are married and/or living outside the household are not taken into account. Moreover, as is usual in African countries, in addition to wives and children, the household accommodates other extended relatives of the household head, such as a mother, father, brother, sister, aunt, niece, nephew, cousin, grandson, granddaughter, sister-in-law, brother-in-law… The number of extended relatives varies greatly from one household to another, from 0 to 12, with an average of 1.5. Half of the households have no extended relative living in.

In total, the household size varies greatly. The smallest household houses 3 members and the largest one 26 members. On average, a household counts about 10 members, which can be decomposed in terms of kinship as shown in table 2.1.

Household education

Household heads education

The majority of household heads (74%) has attended a Koran school named “Daara” in Woloff (the local language) for several years when they were young, learning the Holy Koran. For this reason, some of them can still read or write in Arabic, while others lose these abilities over the years. In terms of formal education, the schooling rate of heads of household is very low. Among 202 household heads, only 17 heads have just attended primary school, 9 have made it to secondary school and only one has reached university level. About 24 of the 202 household heads have not mastered any form of literacy. However, if only formal education is taken into account, 175 household heads are illiterate and 27 are literate. This is equivalent to an illiteracy rate of 87% for household heads, as can be read from table 2.1.

Household members’ education

Regarding other household members, on average 5 members have attended Koran school, while 3 have attended primary school over an average household size of 11 members. This is equivalent to a rate of Koran school attendance of 45% and a rate of primary schooling of 30%. As to secondary education and/or university or superior education, very few household members have reached this level. Eighty percent and 97% of the households have zero members who attained a secondary education or a university degree, respectively. A gender disaggregation of the data shows that 49% of the households have 0% as female primary schooling rate, while 89.5% of the households have 0% as female secondary schooling rate.

In conclusion, the results show low rates of schooling and also a small gender gap. Nevertheless, these results are better than in most rural areas. The horticultural villages are generally relatively large and are located in the proximity of the big cities and roads. Consequently, most of them have primary schools. However, the absence of secondary schools is a constraint. They are obliged to go to cities and this is not easy for some households because of the loss of labour and costs involved.

However, it is important to note that tremendous efforts have been made by the Senegalese authorities to increase the schooling rate, particularly for girls, through awareness campaigns, building schools, and increasing the number of teachers. As a result, the national primary schooling rate, which was about 75% in 2003, amounting to 79% for boys and 72% for girls[6], rose in 2007 to 81% for boys and 79% for girls[7]. A universal primary education or, in other words, a schooling rate of 100%, is one of the major challenges of the Millennium Development Goal (MDG) for 2015.

Household labour endowment

The household labour capacity is calculated as the number of economically active household members, using a scale varying according to the age[8]. Household labour varies greatly from one household to another. It ranges from 2 to 19 economically active members, with a mean of 7.5 (table 2.1). The ratio of the household's economically active members over household size gives the complement of an economic dependency ratio of 0.69. This means that 69% of the household's members are economically active, in others words, each household member depends on 0.69 economically active members. Or, inversely, on one economically active member depend 1.44 household members. Moreover, a gender disaggregation of household labour shows that, on

[6] http://www.education.gouv.sn/statistiques
[7] http://www.unicef.org/infobycountry/senegal_statistics
[8] The number of economically active household members: 7 – 9 years = 0.25; 10-14=0.5; 15-70=1 defined with horticultural households.

average, male labour consists of 4 economically active members and female labour on 3.5 economically active members. This represents respectively 53% and 47% of the overall household labour. The household's labour done by sons and daughters consists of 3.9 economically active members on average; this is 52% of the household labour.

Children constitute an important component of horticultural household labour, due to their great contribution to the different cropping operations. Consequently, child labour by children older than 6 and younger than 15 is estimated. Globally, a household's own child labour plus other child labour gives the total household child labour, which varies from 0 to 4 persons that are economically active, with an average of 0.9. There is no difference between boys and girls.

To the question "Is the family labour sufficient for your horticultural activities?", only 11% of the horticultural households reply "yes". Horticultural cropping is labour-intensive, particularly in developing countries such as Senegal. As a result, most households have insufficient labour to cover the production needs and, subsequently, they employ sharecroppers, hired wage labour and daily hired labour. The number of sharecroppers used per household yearly ranges from 0 to 20, with an average of 2. About 25% of the horticultural households do not use any sharecropping labour contract. The number of daily hired workers varies between 0 and 120 per year, with a mean of 11 persons; they are hired mainly for time-consuming cropping operations like transplanting, weeding and harvesting. About 10% of the households do not used daily labour. Only a few households (7%) are using permanent hired wage labour.

Table 2.1: Horticultural households' characteristics over gender

Characteristics	Household		
	Men	Women	Total
Household headship			
Number	190	13	203
Proportion (%)	93.6	6.4	100
Household kinship composition			
Head	1		1
Wives		1.8	1.8
Children	3.9	2.6	6.5
Other extended relatives	0.5	1	1.5
Household size (total members)	5.4	5.4	10.8
Household education			
Household heads' illiteracy rate (%)	87	77	87
Household members' illiteracy rate (%)	66	80	70
Households with no secondary schooled member (%)	80	89	80
Households with no member with a university level (%)	97	99	97
Household labour *(economically active)*	4	3.5	7.5
Household land ownership *(hectare)*	3.5	0.1	3.6
Household livestock *(number of heads)*			
Cattle	2.6	0.9	3.5
Sheep	2.4	1.4	3.8
Goats	2.7	1.9	4.5
Poultry	2	6	8

Source: Own households survey, 2005-2006.

Emigration within the household

The results of the surveys done by the end 2005 show that some horticultural households count some migrants among their members. The migrants can be the head of household, sons or daughters, or other relatives household members who leave the village to settle in an another city or foreign country. Among 203 households surveyed, 82% of the households have no migrant, while the other 17% of the households count 1 to 6 migrants. However, one year later, at the end of 2006, the number of migrants had increased. Clandestine emigration is becoming an increasing and astonishing movement, affecting horticultural households in particular. In fact, the first reason is that the Niayes Zone is located on the Atlantic Ocean and accordingly, is a departure point of boats transporting migrants. The other reason is that horticultural crops are cash crop;

this provides the cash that affords producers the boat ticket, which costs about fcfa 500,000 (769 euro). In the sample studied, about 8 households were affected by this migration. In this way, the number of households with migrants reached 43 (21%) by the end of 2006.

Two types of migratory flow can be identified according to their destination:

- A domestic flow, generally to Dakar, the capital city, and to other big cities as well as to some major agricultural production and fishing zones (the Senegal River Valley, the coastal zone).
- An international flow, toward the other African and European countries.

In their region or countries of destination, the migrants are engaging in diverse occupations: they work, for instance, as masons, drivers, traders, students, transporters, fishermen, wage workers, or domestic workers. The majority of them have migrated permanently (82%); only some have migrated seasonally.

2.2.2. Horticultural household resources and assets endowment

Resources are the base of any production activity. Diversity among rural households is mainly based on differences in resource endowments (Ruben et al., 2004). After having a look at the household human capital that constitutes the labour, we will now examine the other resources, such as land, livestock and other assets.

Household land ownership

Land ownership varies greatly from one household to another. It ranges from 0 to 20 hectares, with a median of 3. About 75% of the households have less than 5 hectares, and 90% has less than 9 hectares. In most households, land is owned exclusively by men. An exception is formed by some households headed by widowed women who became the “supposed” landowners until the male children will become adults and will marry. Also, in some rare cases, powerful women, strongly involved in horticultural production, manage to buy their own land portion. Only in 34 out of 201 households (17%), women own land, the area ranging from 0 to 10 hectares, with a mean of 0.1 hectare. Only 10% of the female landowners have more than 0.5 hectare.

Because of customary norms rather than religious norms, women usually do not inherit land from their parents, as they are supposed to be away, living with a husband who can provide them with land, of which the woman becomes a tenant rather than an owner. When religious norms and particularly Islamic norms are applied, daughters should inherit half of the sons' share for any asset. However, land is usually sold to the sons, while the daughters get their inheritance share in value rather than in nature or land. Often, the head of household shares out land to his sons when they get married, so there is even no land left for inheritance. In some cases where a woman's husband lives in her parents' village, she can generally inherit a small portion of land from her father, if her father has enough land to cover her brothers' needs. That means that, in all cases, men have priority in terms of access to land as the head of the household and as food provider.

Household total land cropped in horticulture ranges from 0.02 to 10 hectares, with a mean of 1.4. About 10% of the horticultural households produce less than 0.25 hectare in horticulture and about 90% of the households less than 3 hectares. In addition to horticultural crops, some households have other crops, like cereals and peanut during the rainy season, in an area of 0.5 hectare on average. About 50% of the households produce only horticultural crops. Not all the land available is cropped. The land use rate, which is the ratio of land cropped over the total land owned gives an average of 46% for horticultural crops and 59% including other crops. This means that on average households are cropping about 59% of their available land per season, showing some possibilities to scale up the cropped area. While some households are just able to exploit a small part of their land, due to limited means or due to too much land owned, some others own just a very small piece of land that they crop completely, even borrowing or renting additional land. Only 9% of the households are borrowing land and 19% are renting land. The land rent costs, on average, fcfa 200,000 per hectare and season. About 90% of the households are cropping less than 100% of their land in any season. Consequently, in general, land availability does not appear as a major problem.

A gender disaggregation shows that in 60% of the households, women are managing their own plots with a total of land cropped in horticulture ranging from 0 to 3 hectares, with a mean of 0.1 hectare. About 55% of the households have land cropped by women for less than 0.01 hectare and 80% for less than 0.5 hectare. Women exploit small plots, usually allocated by their husband. In about 45% of the households, it is the husband who chooses the plot allocated to his wives (or sisters, mothers …). Only in about 15% of the households, women themselves choose their plots in their husband's field. In 40% of the households, women did not manage their own separate horticultural plots; instead, they just participate on men's plots or engage in other off-farm work, mainly small-scale trading, or deal with domestic work, which is enough of a burden in itself (cooking, cleaning house, washing, fetching water and wood …).

Household livestock

Horticultural households are also cattle breeders. The livestock includes cattle, sheep, goats, horses, donkeys and poultry. The household livestock size varies greatly from one household to another. Some households do not own any livestock or have just a limited number, while others have a livestock well stocked, both in terms of species and the number of heads. Regarding the cattle, sheep and goats, respectively 60%, 45% and 50% of the households have none of them. About 75% of the households have less than 3 heads of cattle, 5 sheep and 5 goats. On average, the household livestock counts 3 to 4 of each of these species. A gender analysis shows that men as well as women are owners of cattle, sheep and goats. However, there is a gender difference regarding livestock ownership within the household. As can be seen from table 2.1, men own more livestock than women, particularly for cattle.

Some households (actually the men) have a horse (22%) or a donkey (38%), used for transportation as well as for animal traction. About 75% of the households have some poultry. Unlike the other animals, poultry is mainly for women. On average, a household has 8 chickens or ducks, of which 2 belong to men and 6 to women.

For cattle grazing, some households use their fallow fields (19% of the households), others use a village grazing area (29%) or a grazing area outside of the village (23%). Some others keep and feed their cattle at home (12%).

In general, livestock plays an important role in the household economy because of its value of reserve and saving. It helps households to overcome hard periods marked by a cash flow deficit. In such periods, households sell some cattle. After harvesting, part of the revenue realized is used to buy cattle. Moreover, for horticultural households, cattle constitute a great source of manure, useful to restore and maintain soil fertility. For women, big cattle as well as poultry is very important to meet emergency needs and to be able to welcome guests warmly with a nice meal.

Other wealth of the household

Housing

Only 6% of the households do not have their own house and generally live in their parents' house. Very few households (6%) live in a straw house. The majority of the households (86%) have their stone wall house with a zinc or slate roof. Some households (8%) have a house with a cemented flat roof (terrace). So, contrary to most Senegal rural areas, the horticultural area knows a great divergence in terms of housing, with well-built houses showing their relatively great wealth or standing compared to others. Obviously, houses belong to men. Only in a few households, the houses belong to women, who then mainly are heads of household (table 2.2).

Transport means

Carts play an important role in the transportation of inputs and outputs. Unfortunately, the majority of the households have no cart (table 2.2). In all households, men are the cart owners, except in three households headed by women. As is quite unusual for rural households, some horticultural households (5%) own a car. All cars belong to men. The car owners are typically men with off-farm work like trade, transport and house building, or men with a pension, or men receiving a remittance from a migrant.

Other appliances

Only 5% of the households do not have a radio while 58% do not have a television. In most of these households, the television belongs to the male heads of household and rarely to female heads or a simple household member (table 2.2). The majority of the villages are not yet electrified and solar panels are used for the television and other household appliance. Freezers and air conditioners are still a luxury for horticultural households, essentially due to the lack of an electric connection. Only 33% of the households do not have a mobile phone. The majority of the households have 1 to 5 mobile phones. Particularly for market price information, the mobile phone is most helpful for horticultural households. A gender disaggregation shows that women are lagging behind. Contrary to mobile phones, landline phones are rare (table 2.2).

Table 2.2: Other wealth of the household

Other wealth of the household	Household		
	Total	Men	Women
Housing			
Household with a straw house (%)	6	6	0
Household with a stone wall house (%)	94	88	6
Household with transport means (%)			
Cart	43	41	2
Car	5	5	0
Household with other appliances (%)			
Radio	95	89	37
Television	42	36	6
Mobile phone	67	66	15
Freezer	10	5	5
Air conditioner	17	15	9

Source: Own households survey, 2005-2006.

Bank account

The analysis of access to financial institutions shows that 40% of the households do not have an account either in a bank or in a micro-financial institution (MFI), while about 60% of households do have one. In 54% of the households, only men have a bank or MFI account, whereas in 6% of the households women have one. However, in some households, the husband borrows money from his bank or MFI and shares a part of his loan with his wives as credit to be reimbursed later. In this way, some women have an indirect access to credit through their husband. Some men have some money in their account, whereas others have an unpaid debt. Men’s account balance ranges from fcfa -500,000 to 1,500,000, with a mean of fcfa 37,500. In more than 50% of the households, men’s account balance is null. In about 75% of the households, men have a balance account of less than fcfa 2,500. In five households, women have an account balance of not null, ranging from fcfa 2,750 to 150,000. For both men and women, these savings have been reserved for the restart of the upcoming horticultural campaign, or are meant to serve as the initial contribution required to get another loan.

2.2.3. Gender and bargaining within the household

In some areas of the Niayes Zone, particularly in the north and centre, women manage their own horticultural plots next to men. In other areas, particularly in the south zone and in a part of the centre zone of Niayes, women work on men's plots and do not have their own separate plots. It is interesting to look at the contribution of men on women's plots, as well as to that of women on the plots of their husband. Moreover, the control of inputs used and the decision-making process within the household must be acknowledged, as well as the control of income earned.

The division of labour on men's plots versus women's plots

On men's plots, women rarely participate in nursery work, land preparation and plant treatment. Inversely, transplanting and harvesting are considered as two of women's specialities. Similarly, in most households (71%), women participate in watering. Women's participation on men's plots in cropping operations, such as weeding, fertilizing, and the application of organic fertilizers in particular, is not general. In a few households (7%), women help men to transport the production, basically in cases in which the household does not have a cart. In about 30% of the households, women participate in the selling of specific crops produced on men's plots.

Evidently, on women's plots, men participate a lot in cropping operations such as the nursery, land preparation and plant treatment, which are considered more or less to be men's speciality. In more than half of the households, the participation of men is recorded in the transplanting, harvesting and selling of products of women's plots. Male participation in the weeding, fertilizing and transport of production on women's plots is noticed as well. Inversely, in the majority of the households (83%), men do not help women to irrigate their plot.

To sum up, as can be seen from table 2.3, a reciprocal participation of men and women is not always generalized in all households for all cropping activities. Some gender specialisation comes up, depending on the type of cropping activity. However, although men and women, or more precisely husband and wives, manage their own plots, they provide each other with a reciprocal labour contribution.

Table 2.3: The participation of women on men's plots and vice versa

Cropping activities	On men's plots, do women participate in this cropping activity? (% of households)		On women's plots, do men participate in this cropping activity? (% of households)	
	Yes	No	Yes	No
Nursery	10	90	69	31
Land preparation	1	99	70	30
Transplanting	75	25	56	44
Weeding	9	91	35	65
Watering	71	29	17	83
Fertilizing	17	83	48	52
Plant treatment	0	100	84	16
Harvesting	89	11	58	42
Transport of production	7	93	47	53
Selling of production	30	70	53	47

Source: Own households survey, 2005-2006.

The control of inputs and the decision-making process within the household

To the question "Who decide which horticultural crops to produce in male plots?", about 91% of the households reply "men themselves" and 9% of the households answer "men with the advice of women". Thus, in the vast majority of the households, men themselves decide on the horticultural crops they grow. Meanwhile, the decision maker of crops to grow on women's plots are the women themselves in 37% of the households, women with the advice of men in 47% of the households, and men in 16% of the households.

Men decided on and paid for all the inputs used in their own plots themselves. This is not always the case on women's plots. About which seed varieties to use, in 35% of the women's plots, men are the decision makers. In 21% of the women's plots, men paid the seed used. With regard to organic and mineral fertilizers, respectively in 13% and 19% of women's plots, men decided on the quantity to be used. In 11% of the women's plots, men paid for the mineral fertilizers and in

4%, for the organic fertilizer, too. In 28% of the women's plots, men decided on the pesticide to be used and paid for it in 12% of the women's plots.

In about 44% of the households, women reimburse to their husband the cost of the input provided. As input providers, men are somewhere decision makers of input choice and the timing of application on women's plots. This creates a kind of dependency of women vis-à-vis men because of (i) a lack of financial means to buy their own input themselves, (ii) or a relative lack of experience compared to men's with regard to input choice and the timing of application, as women are not used to do it, (iii) or men's altruism. This limits the bargaining power of women.

The control of income and the decision-making process within the household

The large majority of the households leave the decision on how to spend a woman's income to herself. In 21% of the households, women decide but with men's advice, while in 3% of the households, it is the men. In 68% of the households, women use their horticultural revenue to satisfy both their own needs and family needs; in 26% of the households, only their own needs; in 4% of the households, only family needs; and in 2% of the households, their husband's needs. To recap, in the large majority of the households, women use their horticultural revenue for their own needs and/or family needs. Women do not co-decide on how men's revenues are spent. This, however, is often spent on family needs, as feeding the family is men's responsibility.

2.2.4. The horticultural household livelihood or income gender-disaggregated

Household horticultural income

A diversity of horticultural crops is grown by the households during the three main seasons. The first horticultural season, which is the most appropriate season with the lowest temperature (about 20^{o} C) and the greatest air humidity, is from around November to February. It is also the most important season, both in terms of the number of crops and the area grown. The second season is from around March to June. The third season is the period covering July to October; it corresponds to the rainy season and is the less important season in terms of the diversity of crops and the area covered. It is the most difficult period of production because of the high infestation of parasites and the high temperatures, to which some crops are not well adapted. Yet, as the supply of horticultural crops decreases during the third season, the prices increase. This is a great motivation for the producers who increasingly step up their efforts to produce during the rainy season. While some horticultural households produce during all seasons and several crops per season, others limit their production to a few crops and one to two seasons.

The revenue earned varies greatly from one season to another, from one household to another, and from men to women. For both men and women, the revenue decreases from season 1 to season 3. Men's horticultural annual income ranges from fcfa 0 to 9,800,000, with a mean of fcfa 1,400,000, while that of women varies from fcfa 0 to 4,720,000, with an average of fcfa 139,000. Accordingly, women earn far less than men. In more than 25% of the households, women do not have any horticultural income.

About 75% of the households earn less than fcfa 2,000,000 per year from horticulture, and 90% of the households earn less than fcfa 4,000,000. There are some households where only men earn money from horticulture and others (basically female-headed), where only women have a horticultural income. Table 2.4 presents in detail the household horticultural revenue and its composition regarding gender and seasons.

The household off-farm income earned by men and women

Off-farm work is defined in this study as all work done other than working on the land plot. Thus, off-farm work includes cattle breeding. In about 45% of the households, no man is doing off-farm work. In the other 55% of the households, men are engaging in off-farm work such as cattle breeding (56/203 households), trade (52), a craft, fishing, transport, forestry, and wage earning. In about 55% of the households, there is no woman doing off-farm work while in the 45% remaining households, women are doing off-farm work such as trade (33% of the households), cattle breeding (15%), the processing of horticultural products, fishing, delivering, a craft, tailoring, weaving, and wage earning.

The off-farm work provides income. Particularly trade constitutes a great source of income for both men and women. While in some households, the off-farm annual income is equal to zero, in the others, it can add up to a relatively great amount both for men (up to fcfa 6 million) and women (fcfa 2.6 million). In almost all of the households engaged in off-farm work (95%), men as well as women found their off-farm annual income to be variable or even very variable over the years. From November 2004 to October 2005, the off-farm income was estimated on average at fcfa 321,000 for men and fcfa 162,000 for women. Men earn more than women, despite the latter's strong engagement in off-farm activities, in particular in small trading businesses, specifically in the southern zone of Niayes and some parts of the central zone of Niayes, too. In these areas, instead of partaking in horticultural production, women engage in small-scale trading, mainly the trading of horticultural products. In this way, they are involved in the horticultural supply chain.

The household remittance received

As analysed earlier, some households have members who have migrated inside of Senegal or to European countries. These migrants, some of whom are even heads of household, send a remittance that can be considered as part of the household income. The remittance ranges from fcfa 0 to 1,2 million yearly, with a mean of fcfa 30,000. More than 90% of the households do not receive any remittance. The frequency of remittances ranges from 1 to 12 per year.

The household total net income

The sum of the horticultural income, other agricultural income, the off-farm income and remittances gives the total annual income (table 2.4). It varies greatly for men, women and the household itself. Men's total annual income ranges from fcfa 0 to 11,020,000, while that of women varies from fcfa 0 to 4,720,000. The household total annual minimum income is equal to fcfa 103,000 and the maximum is fcfa 11,020,000. This means that while some households earn a very low annual income, equivalent to 157 euro, others earn much more, about 16,824 euro. On average, men's annual income is about fcfa 1,800,000 (2,748 euro) while women's income is about fcfa 298,000 (455 euro). Consequently, the household annual income is on average about fcfa 2,100,000, equivalent to 3,206 euro. Thus, per day, the horticultural household income amount to about fcfa 5,753, equivalent to 8.7 euro and 13 US dollars. Divided by the household size, which is about 10 members, the daily income per member is about fcfa 575, or 0.8 euro or 1.3 US dollars. This means that each household member earns less than 2 US dollars a day, which is the poverty threshold. It is, however, more than 1.25 US dollars, which is the new extreme poverty line in developing economies (World Bank, 2009)[9]. Compared to the national poverty line estimated at fcfa 497 in rural areas, based on the national household survey in 2001/02 (Direction de la Prévision et de la Statistique et Banque Mondiale, 2002), horticultural households are living slightly above the poverty threshold. Nonetheless, compared to the majority of the other rural households growing non-horticultural crops and living with less than 1.25 US dollar a day, horticultural households can be considered as the wealthier group. Obviously, horticulture can be considered as an activity which can help to alleviate poverty. “Experience shows that horticulture can offer good opportunities for poverty reduction because it increases income and generates employment.” (Weinberger and Lumpkin, 2007).

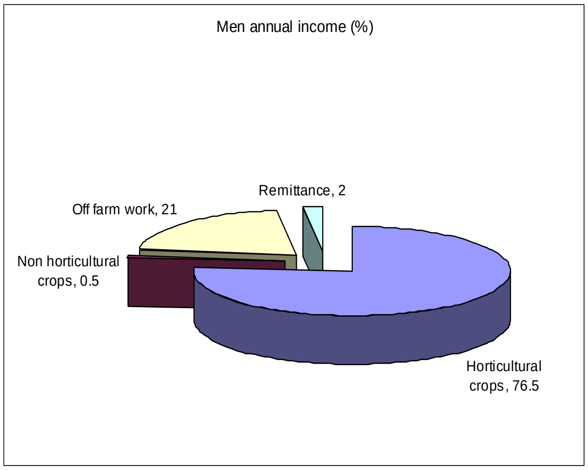
Table 2.4: The household annual income and its composition over gender and season

Variable		Household annual income (fcfa)	Share over gender (%)		Share over seasons (%)		
			Men	Women	First season	Second season	Third season
Horticultural annual income	Mean	1,600,000	84.80	15.20	61.06	29.96	8.97
	Std. dev.	1,700,000	26.00	26.00	24.19	21.32	14.39
Total annual income	Mean	2,100,000	81.76	18.23			
	Std. dev.	1,900,000	24.44	24.44			

Source: Own households survey, 2005-2006.

Horticulture is the foremost source of income, both for men and women. The second source of income is off-farm work. The share of off-farm income is more consistent in women’s income than in that of men. Income generated by the other non-horticultural crops and remittances represents a tiny part of both men’s and women’s annual income, as can be seen from figure 2.1.

9 http://go.worldbank.org/CUQLLRX1Q0



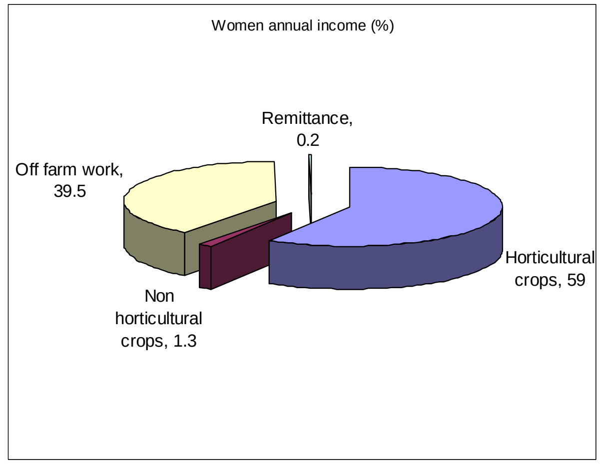


Figure 2.1: Composition of men's and women's total annual income.

2.3. Details on horticultural plots

2.3.1. Plots and managers

The data are considered as cross-sectional data, with the identifier variable household. In total, 422 horticultural plots were surveyed in the Niayes Zone, managed by 279 producers, of which 190 are men and 89 are women, distributed within 203 households. The number of plots range from 1 to 9 per household, from 1 to 5 per male plot manager and from 1 to 4 per female plot manager. The horticultural plot managers were chosen in such a way that they are dispersed in the northern zone of Niayes as well as in the centre and in the southern part. Within each household, next to men, women are managing their own separate plots, particularly in the northern zone of Niayes. In the centre and to a lesser extent in the south zone of Niayes, there are some women managing their own separate plots, but most of them just participate in men's plots and do other off-farm work. This off-farm work consists mainly of the small-scale trading of horticultural crops they bought from their husband and other, surrounding households.

Among the 422 plots, only 19 belong to households that are female-headed, while all the others belong to households that are male-headed. The female plots are 114 out of 422 plots (27%). Table 2.5 represents the distribution of plots by gender and zone.

The social status of male plot managers is head of household, while female plot managers are mainly wives in a polygamous household, holding the status of first wife, second wife or third wife. Generally, the fourth wives did not live with their husband and the other wives. Only a few female plot managers are head of household, or sisters, relatives, or mother of the head of household (table 2.5).

Table 2.5: Distribution of plots over gender, zone and social status of the plot manager

Plots over zone and manager's status	Managers			
	Frequency			Percent
	Men	Women	Total	
Zone				
North	131	74	205	49
Centre	83	10	93	22
South	94	30	124	29
Total	***308***	***114***	***422***	***100***
Social status				
Household head	308	19	327	77.49
First wife		52	52	12.32
Second wife		28	28	6.64
Third wife		8	8	1.90
Sister or female relative		6	6	1.42
Household head's mother		1	1	0.23
Total	***308***	***114***	***422***	***100.00***

Source: Own households survey, 2005-2006.

2.3.2. Horticultural crops

Five of the most frequently cultivated crops, such as onion, cabbage, tomato, green bean and potato, were surveyed. All these crops are destined for the national and sub-regional market. Only green bean is exported to European countries, mainly to France. Except potato, all the other crops are produced by both men and women, in the same order of frequency. Table 2.6 gives the overall distribution of the crops across men and women plots in the sample.

Table 2.6: Distribution of crops across men and women plot managers in the sample.

Crops	Plot managers		
	Men	Women	Total
Onion	110[10] 69.18[11] 38.19[12]	49 30.82 42.98	159 100.00 39.55
Cabbage	100 68.49 34.72	46 31.51 40.35	146 100.00 36.32
Tomato	49 75.38 17.01	16 24.62 14.04	65 100.00 16.17
Green bean	16 84.21 5.56	3 15.79 2.63	19 100.00 4.73
Potato	13 100.00 4.51	0 0.00 0.00	13 100.00 3.21
Total	288 71.64 100.00	114 28.36 100.00	402 100.00 100.00

2.3.3. The horticultural plots' physical condition

Plot area

The plot area cropped varies greatly between households and within the household. Overall, the plot area ranges from 20 m^2 to 1 hectare, with an average of less than 1/5 hectare. About 46% of the plot managers crop less than 1,000 $m^{2,}$ while 5% crops more than 4,000 m^2. A gender disaggregation shows that, with an average of 460 m^2, women's plots are 4.7 times smaller than men's plots, with an average of 2,184 m^2.

[10] Frequency.
[11] Row percentage.
[12] Column percentage.

The plots' physical condition

The plots' soil suitability appreciation

Overall, most of the plot managers found the quality or suitability of their soil to horticulture to be good (77%). Some others (22%) found it medium and very few found it bad (1%). The gender analysis reveals some difference, with fewer women appreciating their plot soil as good (72%) and more women qualifying it as medium (25%) and bad (3%), compared to the overall and men's appreciation frequencies.

The plots' slope appreciation

Overall, 84% of the plot managers well appreciate the slope of their plot. A gender disaggregation also shows that 81% of the male plot managers and 90% of the female plot managers found the slope of their plot favourable for cropping. This means that there is no a priori gender discrimination regarding access to good land.

The plots' soil problem

Overall, almost half of the plot managers affirmed having no soil fertility problem at all on their cropped plots. The others identified as soil fertility problem the scarcity of organic matter (37%), the salinity (7%), a nematode infestation (3%), and the acidity (2%). The number of women plot managers having no soil fertility problem on their plots (45%) is a little bit lower than that of men (50%). For both men and women, the soil problems remained the same in terms of order, but differ a little bit in terms of frequency.

The distance from the house to the plot

The distance from the plot to the house ranges globally, from 0.01 km to 8 km, with a mean of 1.4 km. It varies greatly from one household to another, and less within the household. Women's plots are nearer to the house, with a distance varying from 0.01 km to 5 km and an average of 1.14 km, compared to men's plots, which are located on average 1.45 km from the house.

In terms of the appreciation of the distance from the house to the field, globally, 33% of the plot managers found it near, for 45% it was acceptable, and for 22% it was far. There is no major gender difference in the appreciation of the distance.

***Conclusion*:** To conclude, with respect to plot area and land ownership, a great gender gap occurs. Within the household, most of the female plot managers are not the owner of their land plot; it is mainly their husband's property. In terms of the area, plots cropped by women are much smaller than those of men. However, regarding the physical condition of the plot, no major gender discrimination is noticed. In terms of the plots' soil quality or suitability, the plots' soil fertility problem, the plots' slope as well as the distance from the plot to the house, women in any case are not in an unfavourable situation compared to men.

2.3.4. An evaluation of the plot production cost

Inputs used on men's and women's plots

The quantities of inputs such as seed, organic fertilizer, urea, and NPK fertilizer vary greatly from men's to women's plots, between and within households. As can be seen from table 2.7, there is a great difference in the input used. The quantity of inputs and, consequently, the cost per hectare, are higher on women's plots than on men's plots. As a result, women surprisingly used inputs more intensively than men do. The mean difference between men's plots and women's plots in terms of the quantity and cost of the seeds, organic fertilizer, and urea used per hectare is negative and significantly different from zero at the 5% level. However, the difference in NPK fertilizer and pesticide used on men's and women' plots is not significant even at the 10% level (table 2.7).

Table 2.7: Gender comparison of inputs used per hectare on men's and women's plots within households.

Variables input	Input quantity per plot (kg/ha)				Input cost per plot (fcfa/ha)			
	Men's plots		Women's plots		Men's plots		Women's plots	
	Median	Mean	Median	Mean	Median	Mean	Median	Mean
Seeds[13]	2.50	3.19	3.12	4.03**	166,666	197,081	195,000	330,155***
Organic fertilizer	7,500	13,412	13,500	17,736**	110,000	142,118	145,000	177,448**
Urea fertilizer	340	467	500	704.34***	82,725	113,119	110,000	165,472***
NPK fertilizer	310	413	310	450.05	60,000	74,763	66,666	85,728
Pesticides					40,000	70,039	50,000	85,158

***, ** Gender mean difference significant, respectively, at the 1% and 5% level.

<u>Conclusion:</u> Taking into account the plot area, women use inputs more intensively than men. In terms of decision-making about the use of inputs, some women still remain dependent on their husband. To restore soil fertility and particularly organic matter, and to have a good yield, both male and femlae horticultural producers use a lot of organic and mineral fertilizers, which casts doubt on the quality or appropriateness of the formula of the mineral fertilizers. Moreover, the excessive doses of mineral fertilizers used contribute to increasing the acidity of both the soil and water table, which is becoming a great environmental and public health problem.

Water used on men's and women's plots

Water sources used for irrigation

The sources of water used for irrigation vary, depending on the household's financial capacity and access to information, but also on the zone and the proximity of the water table. Consequently, in the centre zone of Niayes, where the water table is high, households are using traditional non-cemented wells and trench wells. In the north and south zones of Niayes, on the other hand, where the water table is very deep (up to 10 metres), households use cemented wells and water from the SDE (the Water Corporation), respectively.

[13] For seed, only cabbage, tomato, and onion are accounted for. Potato and green bean are not considered because the type of seed is not similar to the previous ones.

The number of traditional wells per plot ranges from 1 to 7 for men and from 1 to 3 for women. As in most cases the land belongs to men, so do the wells. Among the 35 out of 114 women using traditional wells, only 11 are the owners. The number of wells per hectare is 72 on average.

Hydraulic wells or cemented wells are used mainly in the north zone of Niayes and in part of the south; 65% of the male plot managers used it, with a number varying from 1 to 30 wells per plot and with an average of 60 wells per hectare. Among female plot managers, 76% used from 1 to 6 hydraulic wells per plot, but only 24% of these women own their hydraulic wells.

Micro tube wells or boreholes are used only by three men plot managers. In the south zone of Niayes, water from the SDE corporation is used by 5% of the plot managers. This involves 21 plot managers, of whom 17 are men and 4 are women.

Irrigation equipment used on the plot

The sources of water as well as the irrigation equipment used vary greatly, not only from one zone to another, but also between and within households, depending on the gender of the plot manager. For instance, in the centre zone of Niayes, where motorized pumps are used for irrigation, none of the women plot managers has a motorized pump for irrigation, whereas 22.5% of the male plot managers do have one. The women use buckets, ropes and pulleys to fetch water from wells and for irrigation. Twenty percent of the male plot managers used a garden hose as watering material, while none of the women used it. Twelve out of 288 men and 3 out of 113 women plot managers use a sprinkler for watering. Only 6 men and 1 woman use a drip system, covering 1,000 to 5,000 m^2. A proportion of 9.3% of male plot managers use 1 to 52 basins to water their plot, versus 2.6% of the female plot managers, who use 1 to 3 basins.

Conclusion

The sources of water and the irrigation equipment vary greatly from one zone to another, between and within households. In terms of the appreciation of water availability and water quality by men and women plot managers, we have found no major difference. However, while some men plot managers used some improved, less time-consuming irrigation equipment, like a motor pump, women are still using buckets, ropes and pulleys for irrigation. Subsequently, there is a gender gap in terms of irrigation equipment used and regarding the ownership of water sources.

Labour used on the plot

On some plots, only household labour is used, while on others, the managers in addition use hired labour as well. Labour is hired under a wage contract or sharecropping contract.

Labour on plots under household labour

The household members working on the plot consist of the plot manager him- or herself, spouses, sons, daughters, and other parents or relatives (brother, sister, mother, nephew, niece …). The time spent by these household members varies from men's plots to women's plots within households as well as between households. On average, men plot managers spend 177 hours on their plot, whereas women plot managers spend 265 hours. Despite the fact that women's plots are smaller than those of the men, women spend more time working on it. In addition, women spend 32 hours on their husband's plots, while men spend 8 hours on their wives' plots. This can be explained by the fact that the men are polygamous, which means that they have one to three wives working on their plots. While sons work more on their father's plots than on their mother's plots, daughters work more on their mother's plots than on their father's plots. Other household members spend more time on men's plots than on women's plots. In total, more time is spent by household members on men's plots than on women's plots (table 2.8).

Table 2.8: Time spent per plot and season by household members working on men's and women's plots over plots under household labour.

Household members	Men's plots				Women's plots			
	Time (hours)		Time share (%)		Time (hours)		Time share (%)	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Plot manager	177	224	30	34	265	201	59	36
Spouses	32	128	3	6	8	10	2	2
Sons	623	1811	49	40	69	208	13	26
Daughters	49	178	5	15	106	194	19	32
Other members	162	459	13	26	37	116	7	22
Total	1048	1425	100		486	298	100	
Observation (plot)	*153*				*96*			

Regarding the different cropping operations, on men's plots as well as on women's plots, watering is the most time-consuming operation. Watering takes 873 hours of household working time on men's plots and 422 hours on women's plots. In terms of the share of total working time of household members, watering represents 75% and 85% respectively on men's plots and women's plot. This means that watering takes more time on average on women's plots. This can be explained by the difference in irrigation technology used. In fact, women do not have access to a motorized pump or other more sophisticated irrigation material as do men. On men's plots, the use of a motor pump reduces the time spent by household labour per cropped area by 39%. Transplanting, weeding, and harvesting come in second in terms of time consumption (table 2.9).

Table 2.9: Time spent per cropping operation by household members working on men's and women's plots under household labour.

Cropping operations	Men's plots				Women's plots			
	Time (hours)		Time share (%)		Time (hours)		Time share (%)	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Nursery bed	13	22	2	3	6	5	1	1
Land preparation	28	42	3	3	8	13	2	2
Transplanting	38	40	5	7	20	36	4	6
Watering	873	1806	75	21	422	281	85	8
Weeding	42	57	6	8	11	15	3	3
Fertilizing	9	13	2	7	3	3	1	1
Plant treatment	6	12	1	2	2	1	1	1
Harvesting	39	47	6	8	14	9	3	3
Total	1048	1425	100		486	298	100	

Labour on plots under a hired wage labour contract

On 29 out of 422 plots, hired wage labour is used; this is about 7% of the plots. Among the 29 plots, 26 are men's and 3 are women's. The number of workers hired per plot ranges from 1 to 8 on men's plots and from 1 to 2 on women's plots. The hired wage workers are men. The contract duration is 3 months for 86% of the plot managers. For some crops, it can be a shorter (2 months) or a more extended (4 months) period. Plot managers provide hired workers with facilities, such as food provision, housing, health care and others, like a telephone. The most costly facility is food provision, which amounts on average and per season to fcfa 91,788 on men's plots and fcfa 75,000 on women's plots. Housing costs about fcfa 10,000 for both men's and women's plots.

The time spent by wage workers is higher on men's plots than on women's plots. In most of the cases, hired wage labour is paid at the end of the cropping season rather than monthly. This means it is paid after the harvesting and selling of the production on both men's plots (77% of the cases) and women's plots (67%). The total cost of wage labour per plot, including facilities, is on average fcfa 223,000 on men's plots and fcfa 186,000 on women's plots. The monthly wage per hired worker is on average more or less the same on men's and on women's plots (table 2.10).

Labour on plots under a sharecropping labour contract

Under a sharecropping contract, the landowner provides all the required inputs and some facilities, such as housing, food and health care to the sharecropper. In return, the sharecroppers provide their labour force and expertise to produce. At the end of the season, the profit of the production is divided equally over the landowner and the sharecropper.

About 31% of the plot managers use labour based on a sharecropping contract. A total of 110 out of 288 men's plots (38%) and 14 out of 113 women's plots (12%) are under sharecropping labour. The number of sharecroppers used ranges from 1 to 10 on men's plots and 1 to 3 on women's plots. The sharecroppers came from the other regions of Senegal (80.5%), from neighbouring countries such as Mali, Guinea Conakry, Bissau Guinea, Burkina Faso (8.5%), or both from inside and outside of Senegal for the same plot manager (11%). The average age of sharecroppers ranges from 22 to 30 years, with a minimum age of 12 and a maximum age of 49.

A proportion of 54% of the plot managers provides to sharecroppers both feeding and housing facilities, while 30% provides food, housing, and health care facilities, and 8% provides only feeding facilities. Only 8% of the plot managers do not provide any facility; this occurs when sharecropper lives in the same village as the plot-managing landowner.

The sharecroppers' total working time per cropping season is on average 1,325 hours for an average of 2 sharecroppers on men's plots, against 589 hours for an average of 1.1 sharecroppers on women's plots. The average payment per sharecropper is greater on men's plots than on women's plots; this difference is significant at the 10% level. Sharecroppers earn more on men's plots than on women's plots. Per hour, a sharecropper earns on average fcfa 262 on men's plots and fcfa 194 on women's plots. Including the cost of all facilities provided or in-kind payments (food, housing …), the average wage rate per hour and per sharecropper amounts to fcfa 584 on men's plots and fcfa 466 on women's plots.

A worker hired under a sharecropping contract earns more per season than a worker hired under a wage contract, both on men's and women's plots. However, as sharecroppers work more than wage workers in terms of time, their average wage rates per hour are comparable (table 2.10).

Even on plots under a sharecropping or wage labour contract, household labour contributes to time-consuming cropping operations such as transplanting, weeding, and harvesting. The time spent by household labour on plots based on wage labour is greater than that on plots based on sharecropping labour for both men's and women's plots. On plots under a wage labour contract, not only household labour contributes more to the work, but in addition, the plot manager also spends time supervising the hired workers. Table 2.10 recapitulates the time spent by labour and the wage paid by a household to labour over gender and labour contract.

Table 2.10: Labour time and wage over plots under household labour, a wage labour contract and a sharecropping labour contract.

Labour time and wage	Men's plots		Women's plots	
	Mean	Std. Dev.	Mean	Std. Dev.
Labour time				
Plots under household labour				
Total labour time per plot and season (hr)	1048	1425	486	298
Observations (plots)	153		96	
Plots under a wage labour contract				
Hired wage workers' time per plot and season (hr)	536	589	353	295
Household labour time per plot and season (hr)	666	551	533	558
Total labour time per plot and season (hr)	1028	708	822	495
Observations (plots)	26		3	
Plots under a sharecropping contract				
Sharecroppers' time per plot and season (hr)	1325	1492	589	157
Household labour time per plot and season (hr)	246	402	84	64
Total labour time per plot and season (hr)	1552	1553	650	267
Observations (plots)	110		14	
Wage or payment				
Wage labour				
Monthly wage per worker (fcfa/month)	23,425	12,202	20,000	0
Seasonal wage per worker (fcfa/season)	68,545	37,643	60,000	0
Total wage paid per plot (fcfa)	117,980	79,595	100,000	34,641
Wage paid per hour and worker (fcfa)	283		211	
Working time per hectare (hours/ha)	1,697	1,725	425	193
Total wage paid per hectare (fcfa/ha)	315,865	172,399	200,000	69,282
Sharecropping labour				
Seasonal payment per sharecropper (fcfa)	140,008	67,825	107,057	68,469
Total payment of sharecroppers (fcfa/plot)	347,763	462,871	114,200	67,264
Wage per hour and per sharecropper (fcfa)	262		194	
Working time per hectare (hour/ha)	2,481	4,505	1,240	5,414
Total payment per hectare (fcfa)	1,514,172	972,153	1,533,564	563,223

2.3.5. Evaluating the output of the plot

The production and yield per plot

The ratio production and plot area gives the yield, which permits us to make an appropriate comparison between men and women plot managers. Since the crops (onion, cabbage, tomato, green bean, and potato) are all vegetables and have a similar average yield per hectare, it is possible to compare their yield together. For all crops, women's plots yield on average 2.8 kg/m^2, while men's plots yield 2.3 kg/m^2; per hectare, this is 28,979 kg and 23,277 kg, respectively. This difference is significant at the 1% level. Women's plots are smaller than men's plots but yield more per hectare, as can be seen from the box plot graph (figure 2.2).

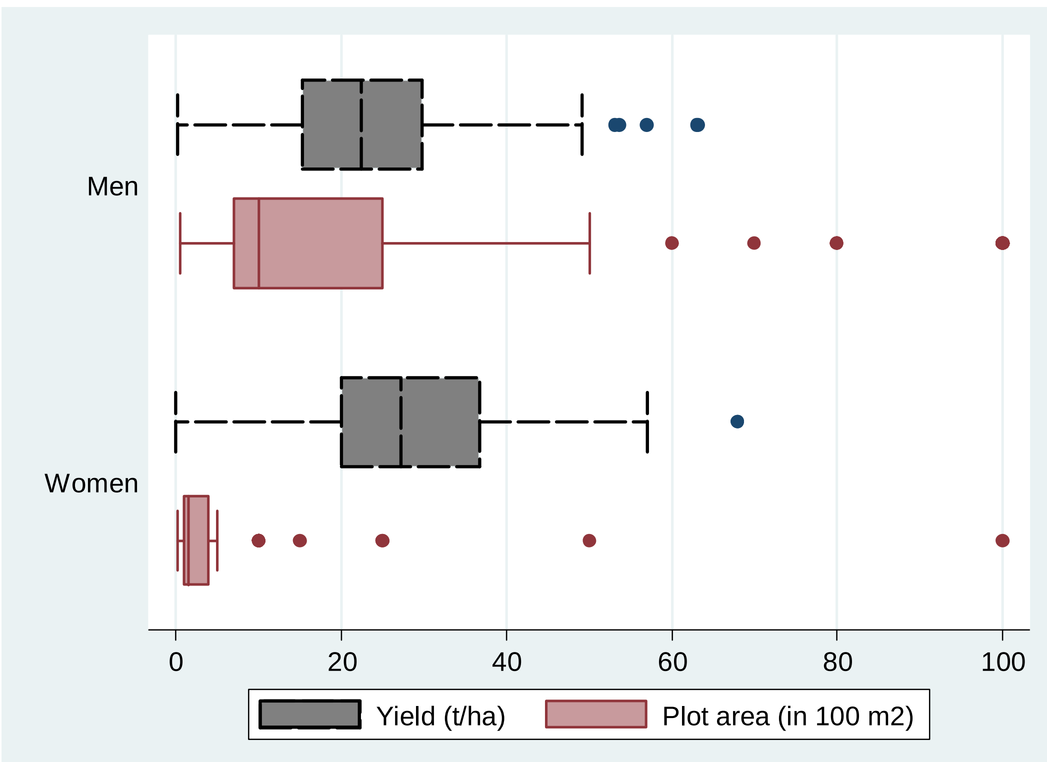
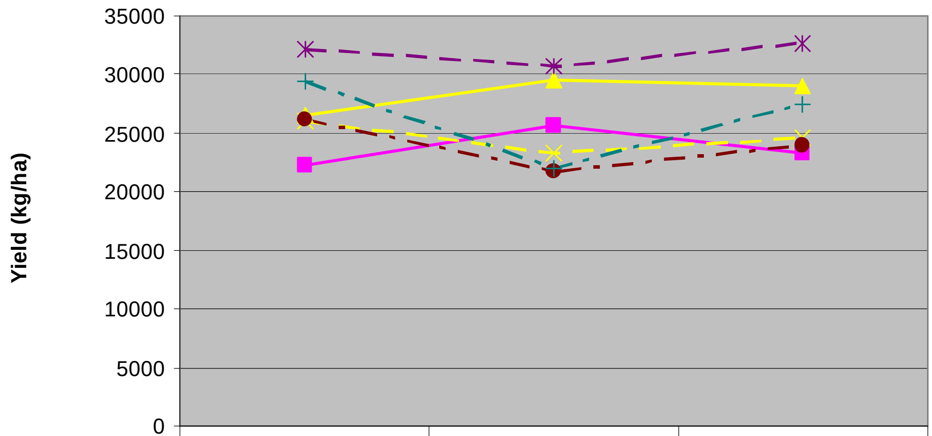


Figure 2.2: Box plots of yield and plot size over the gender of the plot manager.

The analysis of the yield evolution between 2004 and 2006 shows that women's plots yield more than men's plots. The yield varies over the years, but the same tendency is observed for both men and women for all crops and for onion (figure 2.3).



	2004	2005	2006
All crops Men's plots	22203	25692	23277
All crops Women's plots	26549	29496	28979
Onion Men's plots	26064	23243	24625
Onion Women's plots	32106	30701	32707
Cabbage Men's plots	26210	21729	23933
Cabbage Women's plots	29388	21999	27516

Figure 2.3: Gender comparison of the yield evolution over years.

The output price

For most horticultural crops, the harvest does not take place in one go, but is spread over time. The same goes for the selling. Globally, the number of sales corresponding to the number of (partial) harvests ranges from 1 to 10 per crop and plot. Because of a lack of storage and conservation means, the horticultural production harvested is usually sold automatically at the field gate or at the markets. The selling price varies greatly (fcfa/kg 134 to 340) between households as well as within households and from men to women (figure 2.4). The selling price also changes greatly from one harvesting to the next one (fcfa/kg 213 to 268), which usually takes three days to one week and two weeks for the last harvesting. This high price volatility is one of the major risks men and women producers face. Surprisingly, for overall crops, the women's selling prices are almost always higher than those of the men. While for some crops, like onion, the husband usually does the selling, for others, such as tomato and cabbage, the women mostly do the selling. The latter do their selling generally in retail, which allows them to have a better price compared to the men, who sell the production in wholesale. While the women's crops' selling prices increase over time, or from the first to the last harvest, the men's crops' selling prices decrease. This can be seen from graph 2.4 for all crops (onion, cabbage, tomato, green bean and potato) on 402 plots and for tomato on 65 plots.

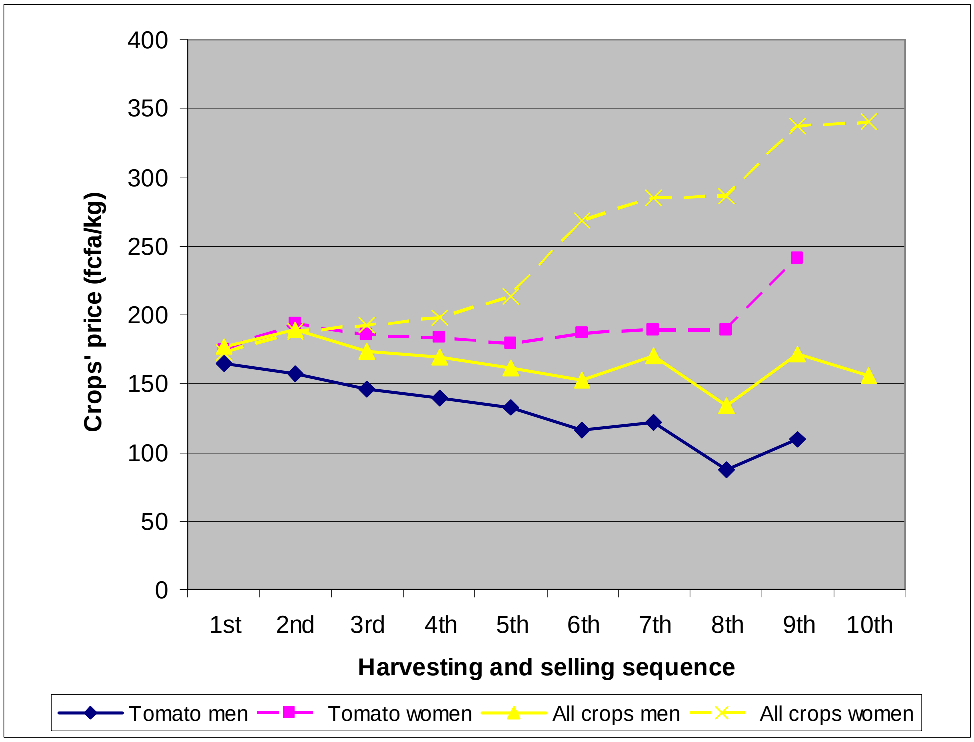


Figure 2.4: Gender comparison of horticultural crops' selling price over harvesting sequence per plot.

The output in value or revenue

Women earn from their plot fcfa 465 per m^2, while men earn fcfa 396 per m^2 on average for all crops. In percent, women's plots bring 17% more output in value per hectare than men's plots do. The difference is significant at the 5% level (table 2.11). Moreover, the output in value or revenue varies greatly for each of the crops from one plot manager to another, for both men and women. In percent, the difference of output in value per hectare between women's and men's plots is 15% for onion, 13% for cabbage, 22% for tomato, and 0% for green bean. Nevertheless, the difference remains not significantly different from zero even at the 10% level for each of the crops (table 2.11).

Table 2.11: Output in value per plot, per hectare, and per crop on men's and women's plots.

Crops	Output in value per hectare (in 1000 fcfa/ha)			
	Men's plots		Women's plots	
	Mean	Std. Dev.	Mean	Std. Dev.
All crops	3,964	3,005	4,656	2,520
Onion	4,380	2,952	5,057	2,785
Cabbage	3,847	3,004	4,361	2,129
Tomato	3,762	2,718	4,615	2,743
Potato	2,508	1,424		
Green bean	2,640	1,641	2,648	808

Conclusion: The horticultural market is characterized by a high variability of the price over time. Taking into account the area, the revenue per hectare is 17% higher on women's plots than on men's plots.

2.3.6. Seasonal effects: a gender comparison of the yield over crop and season

For onion, the yield decreases from season one (November - February) to season two (March - June) both on men's and women's plots. A gender comparison indicates that women's plots yield more than men's plots do for each season, but the difference is significant at the 1% level only on season one. For cabbage, the yield of men's plots is almost the same for seasons one and two and lower in season three, while the yield of women's plots is roughly equal for seasons one and three (July - October) and higher in season two. For all three seasons, women's plots yield more cabbage than men's plots do, but the difference is not significant even at the 10% level. For tomato, on men's plots, the highest yield is observed in season two, followed by seasons one and three. Women's plots yield more in season one than in season three for tomato. In the sample, there is no woman producing tomato in season two and for season three, the number of observations does not allow to do a comparison test. For season one, women's plots' yield is higher than that of men's plots' yield, but the difference remains not significant even at the 10% level. Green bean is cropped only in season one, which is the most appropriate period for production and export. The difference of the green bean yield between men's and women's plots is not significantly different from zero even at the 10% level (table 2.12).

Furthermore, for overall crops, for both men's and women's plots, the output in value per hectare rises from season one to season three. For each season, the output in value per hectare is higher on women's plot than on men's plots, with the difference being significant at the 10% level particularly for seasons one and two. Controlling for onion, the output in value per hectare is higher in season one than in season two for both men and women. The production of onion is not adapted to season three, corresponding to the rainy season. The seasonal comparison also shows that women's output value per hectare is not significantly higher than that of men for the first and second seasons.

Both men and women produce cabbage during the three seasons. For both groups, the greatest output in value per hectare is obtained in season three. As mentioned previously, season three is evidently the most difficult period due to the rainy season, which is characterized by high pressure from plant parasites. More and more, with the newly-adapted seed varieties of cabbage, the production during season three is better controlled by producers, while the high price, due to a low supply, is a great source of motivation. The women's output in value per hectare is higher in season two than in season one, contrary to that of the men. For all the seasons, the women's output in value per hectare is higher than that of the men, but the difference is only significant for season two at the 5% level.

For tomato, the mean output in value per hectare is increasing from season one to season three for men, while it is just the opposite for women. In season one, women's output per hectare is superior to that of men but the difference is not significant even at the 10% level. For green bean, men's and women's output in value per hectare is roughly the same (table 2.12).

Table 2.12: Comparison per crop and season of yield in quantity and in value per hectare over men's and women's plots.

Yield	Crops	Season 1		Season 2		Season 3	
		Men's plots	Women's plots	Men's plots	Women's plots	Men's plots	Women's plots
kg/ha	Onion	**25,026**	**33,032**	23,998	27,942		
	Cabbage	24,148	26,702	24,312	30,160	21,473	27,000
	Tomato	24,367	29,443	28,763		21,308	24,000
	Potato	17,088					
	Green bean	10,184	10,050				
1000 fcfa/ha	Onion	4,413	5,199	4,318	4,701		
	Cabbage	3,450	3,658	**3,449**	**5,464**	5,928	9,173
	Tomato	3,513	4,671	3,906		4,187	3,770
	Potato	2,508					
	Green bean	2,640	2,648				

Note: In bold, gender difference significant at the 5% level.

***Conclusion*:** To sum up, the yield per hectare varies from one season to another. For both men and women, season one and two recorded the highest yield in quantity. Inversely, as the output price rises from season one to season three due to a low supply, it results in an increasing output in value. Except for green bean, for all the other crops, women's plots yield more per hectare in quantity and in value than men's plots do for each of the seasons, but the difference is mostly not significant at the 10% level.

2.3.7. The profitability of crops across gender

The revenue per hectare minus the total costs per hectare of inputs, including seeds, mineral and organic fertilizers, pesticides, water (the connection to the water corporation), fuel (for the motor pump), hired wage labour and sharecropping labour, gives the profit per hectare. The costs of the depreciation of the equipment and household labour are not accounted for. On average, for all crops (onion, cabbage, tomato, green bean, and potato), the profit per hectare is fcfa 2.6 million on men's plots and fcfa 3.7 million on women's plots. Consequently, the profit is 40% higher on women's plots than on men's plots; this gender difference is significant at the 1% level. Controlling for crop, a similar significant gender difference in profit is observed for onion and cabbage (table 2.13). For both men and women, the highest profit is realized with onion, but the difference is only significant with green bean and potato.

Table 2.13: Comparison of profit per hectare across crops, gender, and labour.

Variables	Men's plots (in 1000 fcfa/ha)		Women's plots (in 1000 fcfa/ha)	
	Mean	Std. Dev.	Mean	Std. Dev.
All crops	2,638	2,696	3,699	2,543***
Onion	2,871	2,327	4,162	2,823***
Cabbage	2,659	2,942	3,381	2,100*
Tomato	2,504	2,587	3,554	2,749
Potato	1,214	1,482		
Green bean	1,572	1,255	1,571	1,344

***, **, * gender difference significant at the 1%, 5%, and 10% level, respectively.

Altogether, this descriptive chapter brings to the fore three issues:

1) A great gender gap occurs in the resource and assets allocation, particularly with regard to access to land and irrigation equipment. Mainly the men are the owners of land within the household. In 60% of the households, women are really involved in horticulture, managing their own piece of land, which is usually allocated to them by their husband. Women's plots are 4.7 times smaller than men's plots are. With this small plot size, the intensity of inputs used is higher on women's plots than on men's plots. As a result, women's plots yield 17% more in terms of the output in value per hectare and 40% more in terms of the profit per hectare than men's plots do. Does this imply that women are more efficient than men? This raises the problem of the optimality of the allocation of household resource between men and women.

2) The horticultural production is so labour-intensive that household labour is not always sufficient. In addition to household labour, some households have recourse to hired labour. However, while some households hire labour based on a sharecropping contract, others hire labour based on a wage contract. The returns to a sharecropper from sharecropping per season are on average higher than the seasonal wage paid by the household to a wage worker. Moreover, the most time-consuming cropping operation is irrigation, which takes 75% and

85% of the total working time of household members on men’s plots and women’s plots, respectively. Thus, the time-share of irrigation is on average higher on women’s plots than on men’s plots, because women do not have access to improved irrigation equipment, like a motor pump. A comparison of men’s plots irrigated and non-irrigated with a motor pump shows a decrease by 39% of the working time spent by household members per cropped area when a motor pump is used. Such a context calls for an investigation of the reasons behind the choice of a labour contract, based either on a sharecropping contract or a wage contract. Such a context calls for investigation of the reasons behind the choice of labour contract either based on a sharecropping contract or a wage contract and allowing for the use of labour-saving irrigation equipment like a motor pump. With regard to a household’s profit optimization, what is the efficient labour choice, especially in view of the use of a motor pump?

3) The horticultural marketing context is characterized by a high variability of the output price, which is a major risk that men and women plot managers within a household have to tackle when producing. For the same plot and crop, the selling price of the production varies greatly from one harvesting sequence to the next one, which takes no more than a few days. Such a risky marketing context raises some questions: how do men and women or husband and wives behave when confronting this output market price risk? To what extent are men’s and women’s risk preferences related to their individual and household characteristics? How does their risk behaviour regarding output market price impact upon their economic performance, and particularly on their efficiency in their use of inputs and choice of labour contract?

To find out the answers to all these research questions, raised by this descriptive chapter, is the objective of the next analytical chapters.

Chapter 3.

Household resource allocation, gender and economic performance: efficiency measurement

3.1. Introduction

The economics of the intra-household allocation of resource has undergone substantial changes over the last decades. After the introduction by Nobel Laureate Gary Becker of the New Household Economics, in which he distinguished activities within the household from those outside the household, the approach has changed considerably. While Becker maintained a single objective function for the household, later analyses (McElroy and Horney, 1981; Manser and Brown, 1980) considered households as collective decision-making units. A decision of this unit was seen as the result of bargaining between individual household members. Within this context, the unitary household model would result only as a special case (Alderman *et al.*, 1995). The collective decision model predicted that individual consumption not just depends on the collective income, but also on the individual's own contribution to this income.

More recent studies, such as those by Chiappori (1997), did no longer focus on the distribution of power within the household but on the Pareto efficiency of the allocation. Within the household, a Pareto efficiency of the allocation of resource arises if there is no way to reallocate the resource to make some members better off without making somebody else worse off. In many applications, the allocation of resource in these models came out as efficient, even though income pooling would be rejected (Fafchamps, 1998). Many of the approaches focused on the distribution of consumption goods, and while Chiappori's model related to the labour supply of husband and wife, this was done in an otherwise perfect market setting.

A model that relates to production efficiency within the household is that of Udry (1996). He has shown that yields of plots under the control of women and the control of young adults in Burkinabe rural households were substantially lower than those of the plots of the (male) head of the household. The difference in yield and in the technical efficiency of male and female farmers is a result of lower levels of input use on women's plots, and not of inherent managerial differences between men and women farmers (Adesina and Djato, 1996; Udry, 1996). As illustration, studies carried out in Kenya, Thailand and Korea show that, controlling for education, age, and levels of land, labour, fertilizer and other inputs, female farmers are as efficient as male farmers are (Quisumbing *et al.*, 1998; see also Deere *et al.*, 2004, for Latin America). Yet, as mentioned above, the distribution of resources within the household may be such that the household as a whole is inefficient (Udry, 1996). These results cast doubt on both the collective and the unitary model of the farm household, at least where efficiency is concerned.

The objective of this chapter is to examine the efficiency of the distribution of resources within horticultural households in Senegal. With the gender-disaggregated data collected, this chapter also aims at showing the extent to which the economic performance of the wives deviated from that of the husband heads of household. This chapter intends to shed light on the gender differential between men and women heads of household as well as between the men themselves, whether they manage their plots separately or jointly with their wives, and between the women themselves, depending on their social status. To attain these objectives requires the application of gender-specific economic models to the horticultural households. In doing so, this chapter provides key evidence contributing to an evaluation of the unitary model by illustrating its weaknesses.

As Quisumbing has mentioned, “Despite evidence rejecting the unitary model, the body of research from which generalizations can be drawn is limited. Few studies have been replicated over a range of conditions and cultures (Haddad *et al.*, 1997). Other factors besides policy clearly affect intra-household allocation, such as the extended family, community, and other social groups. More important, existing empirical work in economics may not adequately capture the specific cultural contexts in which individuals within households and families make decisions.”

Using gender-specific stochastic frontier production functions, we have found that women plot managers are as technically efficient as men plot managers are, but neither men nor women are fully technically or allocatively efficient. From the findings, it can be concluded that, from a household perspective, an optimality or allocative efficiency that corresponds to the situation in which an equality of the value of the marginal product of the inputs between men and women’s plots within the household occurs, is far from being achieved for all the inputs. Some improvements can be made in the allocation of inputs, labour, and capital irrigation equipment between men’s and women’s plots, taking into account the value of marginal products. These findings call for some policy implications to become more gender-sensitive, in order to improve men’s and women’s ability to manage their productive resources more efficiently.

The remainder of this chapter is structured as follows. After a review of the literature in the next section, this chapter proceeds to the measurement of the economic performance of men and women plot managers, using indicators such as technical and allocative efficiency to capture and explain the gender differential. Thus, sections 3.3 and 3.4 describe the model used and the empirical specifications. Section 3.5 briefly presents the gender-disaggregated data used for the estimation. Based on the empirical results presented in section 3.6, we will draw a conclusion with some policy implications to end this chapter.

3.2. Literature review

Intra-household resource allocation is marked by gender inequalities. To provide a good understanding of the scientific significance of this research, a review of the literature is done while focusing on two fields:

- The economics of household resource allocation and gender;
- Efficiency as an indicator of performance.

3.2.1. Economics of household resource allocation and gender

Intra-household resource allocation refers to the processes by which resources are distributed among individual household members and the outcomes of those processes (Quisumbing, 2003). Becker has pioneered the investigation of intra-household resource allocation and has initiated the "New Household Economics" (NHE). According to the NHE, a household can be considered as a unit maximising the joint utility of its different members (Akram-Lodhi, 1997). This approach, named the "unitary household model", derives its label from the fact that the household is supposed to act as one or, in other words, to behave as a homogeneous, single entity. Consequently, in the theoretical approach of the NHE, household preferences are represented by a single welfare function. The unitary household model is based on the assumptions that all household resources are pooled and that all expenditures are paid out of pooled income (Haddad *et al.*, 1994).

Much policy analysis was based on Becker's approach, which assumes that the household has a single set of preferences, represented by a household utility function (Haddad et al., 1994). The household unitary model has been the dominant model used by neoclassical economists as a theoretical as well as an empirical tool in the examination of intra-household resource allocation (Akram-Lodhi, 1997). However, despite its predictive power and its relative simplicity, the unitary household model has been criticised by several authors (Bardhan and Udry, 1999; Udry, 1996; Haddad *et al.*, 1994; Akram-Lodhi, 1997; Fafchamps, 1998). Equating the household with one person, household economic theory carries a gender bias, implicitly assuming that the individual making the decision and orchestrating the strategy is the man (Niehof, 1999; Akram-Lodhi, 1997).

Numerous policy levers that are normally able to address development problems did not provide the expected impacts because they were disabled by the assumption that households act as one (Quisimbing, 2003). Many development projects and programmes were concentrated on the male head of household, presuming that he would distribute development benefits within the household unit. Over the past decades, studies have demonstrated not only that individuals within a household make decisions to maximize their individual goals, but also that these goals may even be antithetical to those asserted for the household as a unified entity (Henderson, 1995).

In a gender approach to the household, the division of labour within the household is considered as based on gender, as is the access to and control over resources (Niehof, 1999). Obviously, households reproduce gender roles. No matter where they are located or how they are organized, households recurrently broadcast gender roles to the next generations (Niehof, 1999). The first place of gender specialization is households, passing along knowledge, skills, and social expectations (World Bank, 2001). Children acquire a gender identity that moulds the set of socially acceptable activities for women and men and the relations between them (World Bank, 2001).

Ultimate decision making within farm households on the allocation of resources may be linked to the control of property, resources and income (Akram-Lodhi, 1997). The control of these resources confers relative power on certain specific individuals operating in the household and, subsequently, may establish intra-household gender asymmetries (Akram-Lodhi, 1997). It is apparent that in order to understand these social relations of gender, it is required to move beyond the unitary model and into the household itself, by examining the ways in which relative power is socially constructed and expressed (Akram-Lodhi, 1997). In this regard, the approach of the new household economics is a failure (Akram-Lodhi, 1997).

The NHE unitary approach lacks a gender perspective. Other alternative models called "collective models" have been developed and used by neo-classical economists (Manser and Brown, 1980; McElroy and Horney, 1981) to analyse intra-household resource allocation. The collective models can be divided into cooperative and non-cooperative models on the one hand, and bargaining models on the other (Haddad et al., 1994). However, even if the non-cooperative models can be considered more convenient than the cooperatives ones, they still have some limits with regard to figuring out the inequality in terms of resource allocation and power in the decision-making process. These inequalities may be revealed by conflict and consensus within the household (Akram-Lodhi, 2005) and can be analysed with the bargaining models.

Farm households must have implicit objectives, which motivate rational behaviour. At the very least, they need to survive by fulfilling certain fundamental, basic needs. However, in fulfilling those needs, household members may in many instances attempt to make separate decisions concerning the use of *gender-specific decisions* and *gender-specific production functions* in pursuit of *gender-specific preferences***.** It would be better to say that the farm household does not have a single production function, but rather has *gender-specific production functions* (Evans, 1991, Akram-Lodhi**,** 1997), because the technology used by men and women within the household may be different. The production function measures the maximum possible output that the producer can obtain from a given combination of inputs, which may vary across gender.

One of the scientific contributions of this research lies in testing this assertion by comparing unitary and gender-specific production functions, and broadly, unitary and gender-specific economic models. Next, it tests the Pareto efficiency of the household resource allocation between male and female plot managers while analysing their economic performance. This economic performance is measured using their technical and allocative efficiency as indicators.

3.2.2. Efficiency as an indicator of performance

The explanation of farm performance has been the subject of a multitude of studies, and those focusing particularly on efficiency constitute a main category within that multitude (Bremmer, 2004). Substantial literature has been devoted to the evaluation of efficiency since the pioneering work of Farrell in 1957 (Audibert, 1997). Even in the African region, over the past decades, significant research has scrutinized agricultural efficiency (Seidu, 2008; Kamau, 2007; Tesfay, 2006; Chavas *et al.*, 2005; Ndoye-Niane, 2002; Audibert, 1997; Adesina *et al.*, 1996 ..). The experience of structural adjustment programmes since the 1980s shows how particularly important farm household efficiency is to the African rural economy (Abdulai *et al.*, 2000).

The distinction between ‘efficiency’ and ‘effectiveness’ is that “effectiveness” means “doing the right things”, while “efficiency” means “doing the things right” (Anderson, 1987). Accordingly, effectiveness implies an ability to choose appropriate objectives and goals, while efficiency is an ‘input-output’ objective. The question of how to evaluate efficiency has received considerable attention in economic literature. Efficiency can be defined as the ability to produce a given level of output at the lowest cost. The traditional concept of efficiency, as defined by Farrell (1957), has three components:

- ***Technical efficiency***, which reflects the ability of a firm to obtain maximum output from a given set of inputs, or the capacity to use minimum input to produce a given set of outputs. Then, technical efficiency is attained when the best available technology is used. In this chapter, the technical efficiency across gender will be assessed in section 3.6.3
- ***Allocative efficiency***, which exhibits the ability of a firm to use the inputs in optimal proportions, given their respective prices and the production technology. In other words, allocative efficiency deals with the extent to which farmers make efficient decisions by using inputs up to the level at which their marginal contribution to the production value is equal to the factor cost. Consequently, taking market prices as given, allocative efficiency holds when resource allocation decisions minimize the cost, and maximize the revenue or profit. The allocative efficiency will be examined in section 3.6.2.

- ***Economic efficiency***, which is the combination of technical, allocative and scale efficiency. Economic efficiency, at the micro level, refers to the ability of firms to utilize the best available technology and to allocate resources productively. It is possible for a firm to exhibit either technical efficiency or allocative efficiency without having economic efficiency. Therefore, both technical and allocative efficiency are necessary conditions for achieving economic efficiency (Coelli *et al.*, 1998; Bremmer, 2004; Adesina and Djato, 1996; Ruben, 1997; Abdulai and Huffman, 2000).

The production frontier represents the maximum possible output level related to the given input level, connecting the efficient firms. Firms produce either on that frontier if they are technically efficient, or beneath that frontier if they are technically inefficient (Bremmer, 2004). Efficiency measures can be input-oriented or output-oriented.

In the efficiency literature, a large number of studies explain efficiency using a two-stage approach. The first stage calculates the individual level of efficiency, whereas the second stage explains efficiency by means of a set of socioeconomic and environmental variables. Preferably, all variables representing input and output have to be included in the first stage (Bremmer, 2004; Chavas *et al.*, 2005).

Within the household, Pareto efficiency of the allocation of resource arises if there is no way to reallocate the resource to make some members better off without making somebody else worse off. As pointed out by Alderman *et al.* (1995), many household models are based on the assumption that the allocation of resource is Pareto-efficient. This implies that the distributional implications of household resource allocation and gender are not related to productive efficiency (Alderman *et al.*, 1995). This chapter intends to investigate these issues.

3.3. Gendering efficiency modelling

The measurement of efficiency is generally based on parametric and non-parametric methods. While the parametric approach assumes an explicit functional relationship between output and inputs, the non-parametric approach did not assume any a priori functional form between inputs and outputs and sets a linear, piecewise function from empirical observations. The parametric method, like the stochastic frontier, involves the use of econometric methods, whereas the non-parametric method, like data envelopment analysis (DEA) is based on linear programming. The drawback of a non-parametric approach like DEA lies in the fact that the frontier is deterministic rather than stochastic and, consequently, may be sensitive to outliers, measurement errors, and other noise (Coelli *et al.*, 1998; Dhungana *et al.*, 2004). Although the stochastic frontier method requires some distributional assumptions, it has the advantage of decomposing the error terms in systematic (efficiency) and non-systematic components (random factors and measurement errors). For these reasons, in this study, we opt for the stochastic frontier method.

Particularly, we have used the stochastic frontier production function for cross-section or panel data proposed by Battese and Coelli (1995). The difference is that, in addition to the unitary (or pooled) stochastic frontier model, gender-specific stochastic frontier models are used to better capture the gender difference. The models can be specified as follows:

$$Q_{hijct} = f\left(X_{hijct}, \beta\right).e^{(V_{hijct} - U_{hijct})} \tag{1.1}$$

where:

- Q_{hijct} is the output in value per hectare obtained in household h, for crop c $\in$ {onion, cabbage, tomato, potato, green bean}, on plot i (i=1, 2, ..n), managed by plot manager j who is a male or a female household member (j$\in$ {m, w}), in season t (t$\in$ {1^{st} season, 2^{nd} season, 3^{rd} season});
- X_{hijct} is a (1 * k) vector of inputs used on plot i by plot manager j;
- β is a (k * 1) vector of parameters to be estimated;
- V_{hijct} is the random error term assumed to be independently and identically distributed (IID) N(0, σ_v^2);
- U_{hijct} is referred to as an inefficiency term, assumed to have a strictly non-negative distribution, and obtained from a truncation at zero of the normal distribution N ($Z_{hijct}\lambda$, σ^2), where Z_{hijct} is a (1*m) vector of plot- or plot manager-specific inefficiency variables, and λ is a (m*1) vector of coefficients associated to be estimated.

The inefficiency component U_{hijct} can be modelled as follows:

$$U_{hijct} = Z_{hijct}.\lambda + \varepsilon_{hijct} \ , \qquad U_{hijct} \sim \left| N\left(0, \sigma_u^2\right) \right| \text{ and } \varepsilon_{hijct} \sim N\left(0, \sigma_\varepsilon^2\right) \tag{1.2}$$

The technical efficiency of production of plot i, with crop c and manager j∈{m, w} in season t can be specified as:

$$TE_{hijct} = e^{(-U_{hijct})} = e^{\left(-Z_{hijct}.\lambda - \varepsilon_{hijct}\right)} \tag{1.3}$$

Male and female plot managers within the household are allocatively efficient if the value of the marginal product (VMP) of each input X used is equal to its unit price P_x:

$$VMP(X_{hijct}) = \frac{\partial Q_{hijct}}{\partial X_{hijct}} = P_X \tag{1.4}$$

Optimality or efficiency of the allocation of resources within the household holds if the value of the marginal product of inputs X used on plot i, with crop c and managed by male household members, is equal to the value of the marginal product of inputs X in a similar plot i managed by female household members. In other words, whatever the gender of the plot manager j (j∈{m, w}) within the household, the value of the marginal products of each input should be the same.

$$VMP(X_{himct}) = VMP\left(X_{hiwct}\right) \Leftrightarrow \frac{\partial Q_{himct}}{\partial X_{himct}} = \frac{\partial Q_{hiwct}}{\partial X_{hiwct}} \tag{1.5}$$

3.4. The empirical analysis: functional forms and variables

The results of the data analysis did not show any major gender difference regarding physical conditions of the plots (Chapter 2). The gender difference is only observed for plot area and land ownership. Men's plots are much larger than women's plots and the men are mostly landowners. The gender variation in output is a function of the input used, such as seeds, fertilizers and pesticides, labour, and irrigation equipment.

To avoid multicollinearity between variables, we have used aggregated variables. Initially, a translog functional form was specified, but the interaction variables have been dropped because they are not significant and do not help to improve the specification. For the same reasons, the variables plot characteristics (soil quality, slope ...) have been excluded. The stochastic frontier production function finally estimated is like a fixed-effects model, specified as follows:

$$\log(Q_{hijct}) = \beta_0 + \beta_1 \log(Plot_{hijct}) + \beta_2 \log(Labh_{hijct}) + \beta_3 \log(Labo_{hijct}) + \beta_4 \log(Input_{hijct}) +$$

$$\beta_5 \log(Irreq_{hijct}) + \beta_6 Seas\_01 + \beta_7 Gender\_01 + V_{hijct} - U_{hijc} \qquad (1.6)$$

where the dependent variable logarithm output in value per hectare (Q_{hijct}) is a function of logarithms[14] of :

- $Plot_{hijct}$, the plot area cultivated in hectare,
- $Labh_{hijct}$, the aggregated working time of household members (the plot manager, spouses, sons, daughters, and others) in hours per hectare,
- $Labo_{hijct}$, the aggregated time of hired labour (sharecroppers, male and female hired daily labour, wage labour) in hours per hectare,
- $Input_{hijct}$, the aggregated cost of other inputs used (seed, pesticides, mineral and organic fertilizers) in fcfa per hectare (inputs assumed to be perfect substitutes),
- $Irreq_{hijct}$, the aggregated cost of irrigation equipment used on the plot (a motorized pump, a manual pump, wells, drip systems, sprinklers, seals, ropes, pulleys, …) in fcfa per hectare,
- Seas_01, the dummy variable horticultural season (1 = 1st season and 2nd season, 0 = 3rd season),
- Gender_01, the gender of the plot manager (1 = woman, 0 = man),
- U_{hijc}, time-invariant inefficiency effects or fixed effects measuring heterogeneity.

The model is estimated three times. In effect, to shed light on the gender difference in addition to the unitary stochastic frontier production function (for j = men or women), in which gender is used as an explanatory variable, gender-specific stochastic frontier production functions (for

[14] To handle the cases of plots with zero input or labour, the logarithm of the variable plus one is used: log(variable+1).

j=men and for j=women) are estimated as suggested by feminist development economics theory (Akram-Lodhi, 2005) to make a comparison.

The time-invariant inefficiency frontier component U_{hijc} is specified as follows :

$$U_{hijc} = \lambda_0 + \lambda_1 Zone_{hijc} + \lambda_2 Seplot_{hijc} + \lambda_3 Edu_{hijc} + \lambda_4 Head_{hijc} + \lambda_5 Wstat_{hijc} + \lambda_6 Age_{hijc} + \lambda_7 Mw_{hijc} + \lambda_8 Ww_{hijc} + \lambda_9 Cred_{hijc} + \lambda_{10} Ext_{hijc} + \lambda_{11} Moff_{hijc} + \lambda_{12} Woff_{hijc} + \varepsilon_{hijc}, \quad \varepsilon_{hijc} \sim N(0, \sigma^2) \tag{1.7}$$

where the technical inefficiency effects U_{hijcs} are defined as a function of:

- $Zone_{hijc}$, the dummy variable location (0=Zone North, 1=Zones South and Centre),
- $Seplot_{hijc}$, husband and wives within the household are managing theirs plots separately or jointly (1=separate plots, 0=joint plots),
- Edu_{hijc}, the household head's education level (1 = formal schooling, 0 = Koranic school and illiteracy),
- $Head_{hijc}$ the plot manager's head status (1 = household head, 0 = otherwise),
- $Wstat_{hijc}$, the women's plot manager status (1 = 1st wife, 0 = 2nd wife, 3rd wife, and other, like mother, sister, or female relative),
- Age_{hijc}, the age of the plot manager (in years),
- Mw_{hijc}, the number of male household members working on the plot,
- Ww_{hijc}, the number of female household members working on the plot,
- $Cred_{hijc}$, the plot manager's access to credit (1 = access to credit, 0 = otherwise),
- Ext_{hijc}, the plot manager's access to extension services (1 = access to extension services, 0 = otherwise),
- $Moff_{hijc}$, the share of men's off-farm income in their total income,
- $Woff_{hijc}$, the share of women's off-farm income in their total income.

These variables are hypothesized to have an effect on the inefficiency of male and female plot managers. Like the production functions, the inefficiency model is estimated three times: for j = men or women (unitary model), for j = men, and for j = women (gender-specific models).

The allocative efficiency of resources within the household is examined through the comparison of the value of the marginal product (VMP) of inputs on men's and women's plots. As the production function estimated is log-linear, the coefficients β correspond to the elasticity of the production Q, observed in value per hectare with respect to input X:

$$\beta = \frac{\partial \log Q_{hijct}}{\partial \log X_{hijct}} = \frac{\partial Q_{hijct} / Q_{hijct}}{\partial X_{hijct} / X_{hijct}} \tag{1.8}$$

So:

$$VMP(X_{hijct}) = \frac{\partial Q_{hijct}}{\partial X_{hijct}} = \beta \frac{Q_{hijct}}{X_{hijct}} \tag{1.9}$$

3.5. The data

As presented in the descriptive chapter, gender-disaggregated data were collected from 203 horticultural households located in the Niayes zone, in Senegal. Within the households, men and women or husband and wives are generally managing their plots separately. From the 203 households, a total of 422 horticultural plots have been surveyed, of which 308 plots are managed by men and 114 plots are managed by women. The major horticultural crops are onion, cabbage, tomato, green bean and potato, which are grown by both men and women. Thus, to better control for crop, these crops were chosen. For this reason, in this sample, men and women produce the same horticultural crops.

Table 3.1 presents the gender comparison of the data used in the production functions estimated. Plots cropped by men are much larger than those of the women. Women's plots are more intensive than men's plots in terms of inputs (seeds, mineral and organic fertilizers, pesticides) and household labour used per hectare. However, men make more intensive use of hired labour (sharecropping, wage labour, or daily hired labour) than women do. Women's plots yield more in terms of value per hectare than men's plots. The gender difference in inputs and output is significantly different from zero at the 10% level, showing some dissimilarities in technology. It motivates the need to test the convenience of using gender-specific production functions rather than a unitary or pooled production function in order to better capture the gender difference.

Table 3.1: Gender comparison of the means of the variables used in the production functions.

Variables	Men and Women	Men	Women	t-statistics (H0: Men-Women=0)
Output (fcfa/ha)	4,159,506	3,964,871	4,656,523	-2.15**
Plot (ha)	0.17	0.22	0.05	7.57***
Labh - Household labour (hr/ha)	14,472	7,292	32,550	-10.64***
Labo – Hired labour (hr/ha)	2,239	2,509	1,513	1.92**
Input (fcfa/ha)	608,661	562,747	732,710	-3.29***
Irreq – Irrigation equipment (fcfa/ha)	3,623,587	3,298,710	4,444,479	-1.83*

***, **, * significant at the 1%, 5% and 10% level, respectively.

3.6. Empirical results and discussion

3.6.1. Estimation of unitary and gender-specific stochastic frontier production functions

The Maximum Likelihood (ML) of the Frontier programme of Stata for cross-sectional and panel data is used to estimate the parameters. Since the data used are cross-sectional with the household as the first sampling unit and plot as the second one, the household is used as identifier to allow for household heterogeneity. Therefore, since the fixed-effects specification is estimated as a within estimator, the consistency of the estimates does not need any assumption about endogeneity or correlation between the regressors and the inefficiency effects, as shown by Abdulai and Tietje (2007). In addition, the maximum likelihood is used as estimator and, consequently, the estimates are consistent and efficient as long as the distributional assumptions are correct (Verbeek, 2008).

As can be read from table 3.2, apart from the dummy variable horticultural season, as expected, the other β coefficients are all significant and positive, except for plot area and aggregated irrigation equipment cost in the unitary and men-specific stochastic frontier production functions. In the women-specific stochastic frontier production function, all the β coefficients are positive, showing some difference between the models. However, the gender dummy variable of the unitary model is positive but not significant, casting doubt on a fixed proportional gender difference.

The unitary model or pooled model shows that the variables cost of inputs (seed, mineral and organic fertilizers, and pesticides), household labour, hired labour, and horticultural season are statistically significant at the 10% level. The effect of the season confirms the results of the seasonal comparison (see Chapter 2). Producing in the first and second seasons decreases output in value per hectare, because of the relative low output market price compared to the third season. The yield response to plot area cropped and capital equipment is negative but not significant at the 10% level.

Considering the men-specific stochastic frontier production function, the coefficients of the variables show the same direction in terms of sign, magnitude and significance, compared to the unitary model particularly for inputs, household, and hired labour. Consequently, the analysis of the effects of these variables leads to the same conclusion as the unitary model. This is obviously influenced by the large share of male plots in the total number of plots. Unexpectedly, capital irrigation equipment is significantly and negatively related to output in value per hectare, indicating that male plot managers using more costly irrigation equipment, like motor pumps, did not achieve a higher yield in value per hectare compared to those using a rudimentary irrigation system based on buckets and ropes to fetch water from the wells. This irrigation system based on buckets and ropes is really meticulous and, as a result, yields more per hectare but is very time-consuming. Thus, it constraints plot managers to crop small plots, whereas the use of a motor pump allows for large-scale production.

Regarding the women-specific frontier production function, like the unitary and men-specific models, hired labour working time and inputs cost have positive and significant effects on the output in value per hectare. Contrary to the unitary and men-specific models, irrigation equipment cost is positively and significantly related to the output in value per hectare, while household labour and the seasonal effect are not significant at the 10% level. Obviously, the women-specific stochastic production function presents some differences compared to the men-specific model and the unitary model, as can be read from table 3.2.

Table 3.2: Maximum Likelihood estimates of the unitary and gender-specific stochastic frontier production functions for cross-sectional and panel data.

Dependent variable log output in value per ha: log(Q/ha)	Unitary stochastic frontier production function		Men-specific stochastic frontier production function		Women-specific stochastic frontier production function	
Explanatory variables	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Log(Plot)	-0.031	0.230	-0.144	0.253	0.773	0.749
Log(Input/ha)	0.273	0.053***	0.311	0.069***	0.164	0.087**
Log(Labh/ha)	0.065	0.028**	0.075	0.035**	0.085	0.057
Log(Labo/ha)	0.042	0.011***	0.051	0.014***	0.033	0.017**
Log(Irreq/ha)	-0.044	0.034	-0.116	0.041**	0.137	0.072**
Seas_01	-0.238	0.131*	-0.241	0.147*	-0.314	0.263
Gender (1=female)	*0.095*	*0.075*				
Constant	11.895	0.705***	12.331	0.868***	10.615	1.344***
σ^2	1.244	1.422	1.567	2.436	1.860	7.696
$\gamma = \sigma_u^2/\sigma^2$	0.817	0.207	0.850	0.230	0.922	0.316
σ_u^2	1.017	1.420	1.333	2.433	1.716	7.688
σ_v^2	0.227	0.021	0.234	0.028	0.143	0.029
Log likelihood	-317.78		-238.53		-71.77	
Nb. Obs. (plots)	377		271		106	
Nb. Group (household)	176		162		62	
Obs. per group: Min	1		1		1	
Avg	2.1		1.7		1.7	
Max	9		5		4	
Wald chi2(7-6)	72.94***		42.70***		29.39***	
Wald chi2(1): H0:CRT	0.02		0.32		1.06	
Likelihood-ratio test: LR chi2(9)	14.95*					

***, **, * significant at the 1%, 5%, and 10% levels, respectively.

As the estimation is based on the ML method rather than the OLS method, the Chow test cannot be performed to compare the unitary and the gender-specific models. The equivalent or alternative test for models fitted via ML is the likelihood ratio test. The null hypothesis test is: the estimates are the same for both the unitary model and the gender specific-models. As can be read from table 3.2, the null hypothesis is rejected. The likelihood ratio test shows that all the estimates of the unitary and gender-specific models are significantly different at the 10% level. Consequently, men's stochastic frontier production function differs significantly from that of the women. In other words, there is some difference in the technology used by men and women plot managers. However, from an econometric point of view, is there any gain in estimating the unitary model rather than the two gender-specific models? The sum of the log likelihood of the gender-specific models is a little bit greater (closer to zero) than the log likelihood of the unitary model (-238.53 – 71.77 = -310.30 > -317.78), econometrically showing some efficiency gain while estimating the gender-specific models rather than the unitary model.

A careful examination of the coefficients corresponding to the output elasticity, as the models are in logarithmic form, reveals some differences that are economically important. These support the use of gender-specific models rather than the unitary model to better capture the gender difference. For instance, an increase by one percent of inputs leads to an increase by 0.31% of output in value per hectare according to the men-specific model, and to an increase by 0.16% according to the women-specific model. Capital irrigation equipment provides another example, with an output elasticity of 13% on women's plots. Thus, the gender difference in effects of extra inputs and capital irrigation equipment are economically meaningful; they illustrate the interest of using gender-specific models to highlight such a gender difference. Including a gender dummy variable (1=female plot manager) as the explanatory variable in the unitary model, as is usually done, is not enough because the gender variable comes out not significant (P=0.20). Rather, to allow for such a gender difference, the alternative of the gender-specific models would be to interact each of the explanatory variables with the gender dummy and to add the interaction variables to the unitary model. From this results a positive and significant (P=0.001) interaction of gender with capital irrigation equipment and a negative and significant (P=0.003) interaction of gender with input. Being a female plot manager increases the effect of irrigation equipment on output in value per hectare and decreases the effect of input. The likelihood ratio test does reject the assumption that the unitary model with a gender dummy is nested in the unitary model with the explanatory variables interacted with gender at the 1% level. The test of parameters also confirms that the variables interacted with gender are jointly significantly different from zero at the 1% level. To sum up, from the gender-specific models, it can be concluded that while in terms of value per hectare, men's plots are more responsive to a change in inputs, women's plots present a greater responsiveness to a change in capital irrigation equipment. This reflects the reality that women's plots are very small and have low-capital irrigation equipment, but are intensively worked.

Since in the stochastic frontier production functions estimated, the variables (value of output, household and hired labour, non-labour input and capital irrigation) are on a per hectare basis, the return to scale or scale elasticity is equal to $1+\beta_1$[15]. It is equal to 0.97 for the unitary model, 0.86 for the men-specific model and 1.77 for the women-specific model. Consequently, when household and hired labour, input and capital irrigation (all inputs) are scaled up by one unit, the output in value per hectare will go up by 0.86 units on men's plots and 1.77 units on women's plots. Thus, women's plots are more responsive with regard to a change of scale of production than men's plots are. The returns to scale for men are lower than one, while for women they are greater than one, showing that the technology displays decreasing returns to scale on men's plots and increasing returns to scale on women's plots. This is consistent with the interpretation that women's plots are too small and under the optimum size. This may be explained mainly by their labour constraint and by their land constraint as well. Women do not have any access to labour-saving irrigation technologies, like a motor pump. In addition, women are usually not the landowner; they just benefit from a portion of their husband's land. However, the Wald test of constant return to scale (H0: CRT), done by imposing the sum of the coefficients equal to one ($1+\beta_1=1$ or $\beta_1=0$), does not reject the constant return to scale for the unitary and the gender specific-models at the 10% level (table 3.2).

3.6.2. Gender and the efficiency of the allocation of resources within the household

For a further comparison of the efficiency of the allocation of resources between men and women plot managers within the household, we need to measure and compare the marginal product of the main inputs used. The marginal product refers to the increase in output resulting from one unit increase in input, assuming that all other inputs are constant. From a household perspective, the efficiency of the allocation of inputs between men's and women's plots within the household

[15] $\text{Log(Qtotal)} = \beta_0+(1+\beta_1)\log(\text{Plot})+\beta_2\log(\text{Labh/Plot})+\beta_3\log(\text{Labo/Plot})+\beta_4\log(\text{Input/Plot})+\beta_5\log(\text{Irreq/plot})$
$=(1+\beta_1-\beta_2-\beta_3-\beta_4-\beta_5)\log(\text{Plot})+\beta_2\log(\text{Labh})+\beta_3\log(\text{Labo})+\beta_4\log(\text{Input})+\beta_5\log(\text{Irreq})$
Return to scale= $1+\beta_1-\beta_2-\beta_3-\beta_4-\beta_5+\beta_2+\beta_3+\beta_4+\beta_5=1+\beta_1$
Production elasticity of land= $1+\beta_1-\beta_2-\beta_3-\beta_4$

implies an equality of the value of the marginal product of the inputs between men's and women's plots. If the value of the marginal product of a variable input used by men and women is equal to its unit price, the household is allocatively efficient. The unit prices correspond to the rent per hectare and per season for land, to the wage rate per hour for labour, and to one for other inputs and capital irrigation equipment, because their costs are used rather than their quantity.

The results of the gender comparison indicate that, based on both the unitary model and the gender-specific models, the value of the marginal product of land, inputs, labour, and irrigation equipment differs from men's to women' plots within the household, as can be read from table 3.3. Consequently, one unit change in these production factors leads to a change in output that is significantly different at the 10% level from men's to women's plots. Except for input, the gender differences in the value of the marginal products predicted from the unitary model and the gender-specific models have the same sign, although they differ in terms of magnitude. The gender-specific models display greater gender differences in the value of the marginal products than does the unitary model. Altogether, in addition to the gender difference in the technology used, the gender distribution of the resource within the household has implications for the allocative efficiency. The value of the marginal product of land is higher on women's plots than on men's plots as shown by the ratio, which is lower than one. More specifically, an increase of land cropped by one hundred square meters, holding all other inputs constant, will rise the output by fcfa 21,000 and 63,000, respectively, on men's and women's plots, based on the gender-specific models. The value of the marginal product of inputs, household labour, and hired wage labour is higher on men's plots than on women's plots, as shown by the ratios, which are greater than one. However, the value of the marginal product of irrigation equipment is higher on women's plots than on men's plots, where it is negative. Altogether, while within the household, land and irrigation equipment are better valued on women's plots, labour and others inputs are better valued on men's plots, as can be read on table 3.3.

Table 3.3: Gender comparison of the Value of the Marginal Product of inputs within the household.

Variables	**Value of the Marginal Product (VMP)**						Unit price
	Unitary model		Gender-specific models				
	Men	Women	Men (VMPM)	Women (VMPW)	t-statistic (VMPM-VMPW)	VMPM / VMPW	
Land (fcfa/ha)	2,528,696 (1,120,349)	2,980,175 (681,120)	2,133,587 (945,294)	6,379,436 (1,458,024)	-12***	0.33	200,000
Inputs	2.18 (0.93)	2.46 (2.35)	2.50 (1.07)	1.45 (1.39)	4.66***	1.72	1
Household labour (fcfa/hr)	346 (740)	59 (48)	404 (864)	79 (64)	4.13***	5.11	142-285
Hired wage labour (fcfa/hr)	785 (175)	322 (34)	982 (219)	242 (25)	1.82*	4.05	310
Capital irrigation equipment	-0.20 (0.52)	-0.08 (0.05)	-0.57 (1.43)	0.26 (0.16)	-5.44***	-2.19	1

***, * significant at the 1% and 10% level, respectively. Standard deviation within the household in parenthesis.

From the findings, it can be concluded that, from a household perspective, an optimality or allocative efficiency that corresponds to the situation under which an equality of the value of the marginal product of the inputs between men and women's plots within household occurs is far from being achieved. Some improvements can be made in the allocation of land, inputs, labour, and capital irrigation equipment between men's and women's plots, taking into account the value of the marginal product. This result corroborates findings by Udry (1996) and by Alderman *et al.* (1995) in another way by using an additional step, comparing the value of the marginal products of factors of production. The results imply that a shift of land and capital irrigation equipment from men's plots to women's plots and a shift of labour and inputs from women's plots to men's plots will lead to more output in value per hectare for the household.

Furthermore, beyond an intra-household perspective, allocative efficiency reflects the ability of men and women plot managers to combine inputs profitably, so as to equalize the value of the marginal products of the inputs to their unit prices. Accordingly, neither men nor women plot managers did achieve absolute allocative efficiency. Regarding land, for both men and women, the value of the marginal product is much higher than the average rent per season and per hectare, which is about fcfa 200,000. Consequently, men and women would increase their output in value per hectare if they would enlarge their cropped land. Inefficiency in the use of land persists because of the low average rent, which may be due to institutional constraints, arrangements with family or friends, and differences in soil quality between owner-operated plots and rented plots. With the limited access to credit, very few households can rent out land. Usually, the rent is arranged between family members or friends, and so is fixed as low as possible. Land cropped by producers may have a better quality than rented land. The producers keep the best land for their own production, and invest in it to maintain the soil fertility.

With respect to inputs (seed, fertilizers and pesticides), the value of the marginal product is higher than one, suggesting that both men and women should use more inputs to increase their output in value per hectare. Thus, men as well as women plot managers are not allocatively efficient with respect to inputs used; this finding is in line with Alene *et al.* (2008). Figure 3.1 depicts the kernel density estimation of the distribution of the value of the marginal product of inputs and land over gender.

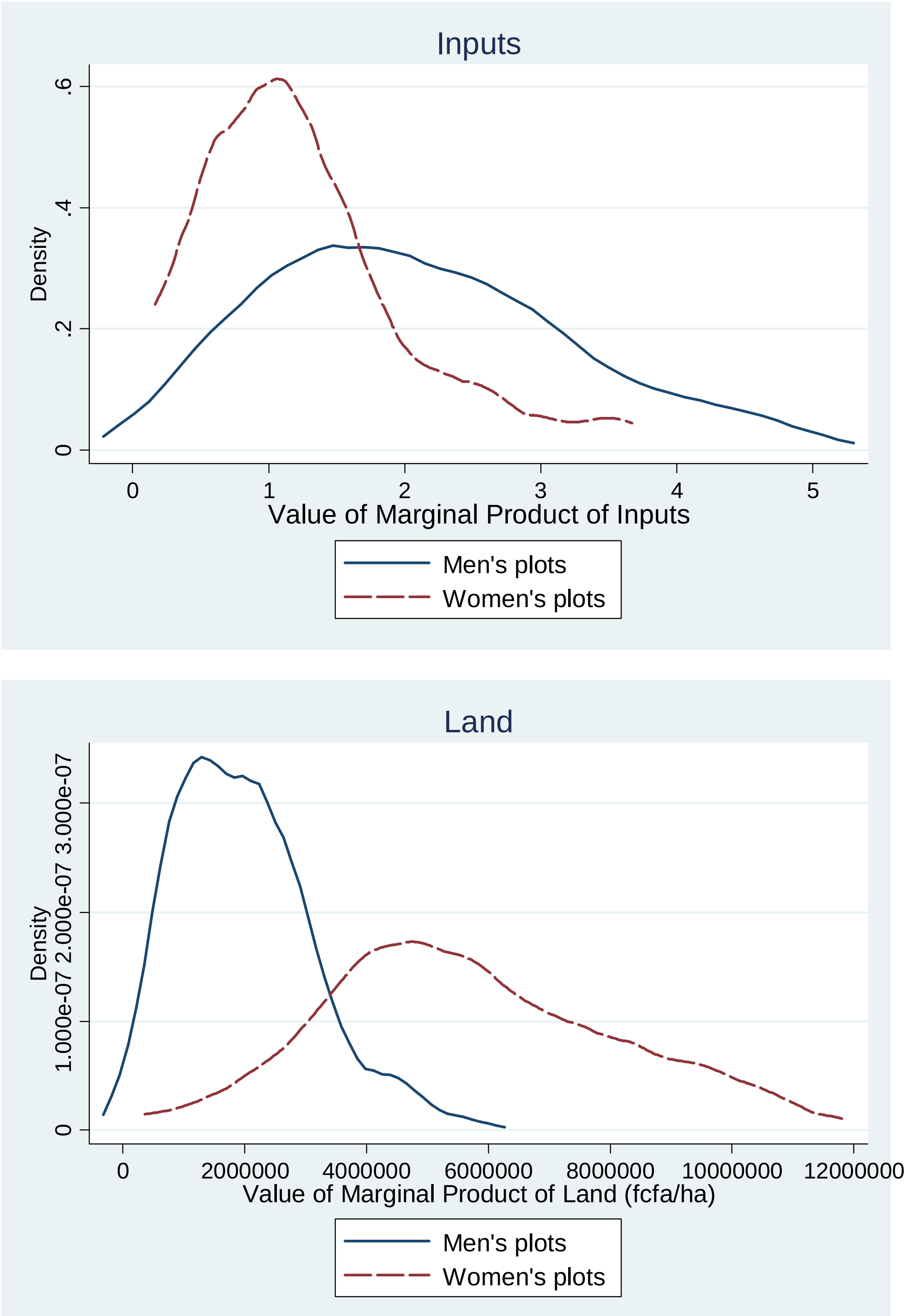


Figure 3.1: Gender comparison of the distribution of the value of the marginal product of inputs and land.

The market hourly average wage rate is about fcfa 142-285 (1,000 – 2,000 per day) for unskilled workers. Thus, considering household labour, on men's plots the value of the marginal product is higher than the market wage rate, whereas it is lower than the market wage rate on women's plots. Similarly, on men's plots, the value of the marginal product of hired labour is higher than the average hourly wage rate paid by the horticultural household to a hired wage worker, estimated at fcfa 310, while on women's plots, the value of the marginal product is lower than the average wage rate paid. This implies that on both men's and women's plots, the allocation of household and hired labour is not efficient. Figure 3.2 depicts the kernel density estimation of the distribution of the value of the marginal product of hired wage labour, but only on men's plots, because only a few women hire wage labour.

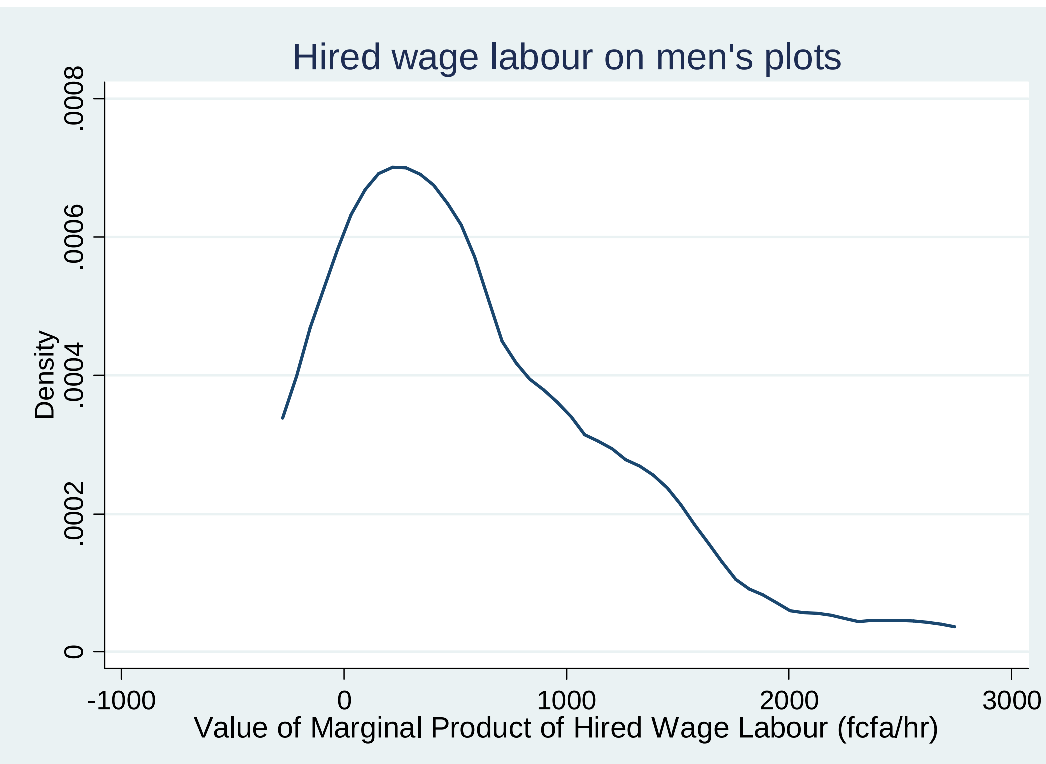


Figure 3.2: Kernel density estimate of the distribution of the value of the marginal product of hired wage labour on men's plots.

Considering irrigation equipment, the value of the marginal product is negative on men's plots and positive on women's plots, but lower than one. Even if the improvement of irrigation equipment allows some male plot managers to increase the area cropped, it is not followed by an increase of their output in value per hectare compared to the less equipped male plot managers. The negative sign of the value of the marginal product of irrigation equipment in reality does not mean an over-equipment or an over-investment. Rather, it shows inefficiency on the valorization of the equipment. A disaggregation of the irrigation equipment shows that, on women's plots, the value of the marginal product of irrigation equipment is close to one when sprinklers are used. Consequently, to improve their efficiency, female plot managers need to have better access to improved labour-saving irrigation equipment to reduce their labour, to enlarge their cropped area, and also to increase their output in value per hectare.

3.6.3. Technical efficiency across gender

3.6.3.1. Technical efficiency scores and its distribution across gender

The technical efficiency scores are predicted from the stochastic frontier production functions estimated. From the unitary stochastic frontier production function, the overall mean technical efficiency is estimated at 0.73 for both men and women, with a minimum of 0.23 and a maximum of 0.91 (table 3.4). This means that some plot managers have a very low technical efficiency, while none of the plot managers have reached the frontier level, in other words, none of them are fully technically efficient. A gender disaggregation of the technical efficiency predicted from the unitary model gives an average technical efficiency index of 0.73 for men and 0.74 for women plot managers. Consequently, based on the unitary model, men and women exhibit the same technical efficiency, since the difference is -0.01 and is not significant even at the 10% level. These results differ from those derived from the gender-specific models.

The men-specific stochastic frontier production function indicates an average technical efficiency of 0.75, with a minimum of 0.24 and a maximum of 0.90. Based on the women-specific stochastic frontier production function, the female technical efficiency index ranges from 0.39 to 0.94, with an average of 0.81 (table 3.4). It is difficult to make a comparison between the scores achieved by men and women from the gender-specific models because the frontiers are not the same. The gender-specific models show that both men and women exhibit higher efficiency scores in their own gender group than in the whole group.

Table 3.4: Gender comparison of technical efficiency scores using unitary and gender-specific stochastic frontier production functions.

Stochastic frontier production functions	Gender group	Technical efficiency (TE)				
		Mean	Std. Dev.	Min.	Max.	Obs.
Unitary model	Men	0.73	0.148	0.23	0.91	308
	Women	0.74	0.144	0.25	0.91	114
	Men and Women	0.73	0.147	0.23	0.91	422
	Difference (Men TE – Women TE)	-0.01				
	T	-0.81 (H0: Men TE – Women TE = 0)				
	Pr (|T|> |t|)	0.41				
Men-specific model	Men	0.75	0.136	0.24	0.90	308
Women-specific model	Women	0.81	0.104	0.39	0.94	114

Figure 3.3 presents the cumulative distribution of the technical efficiency by gender, based on the unitary model and the gender-specific models.

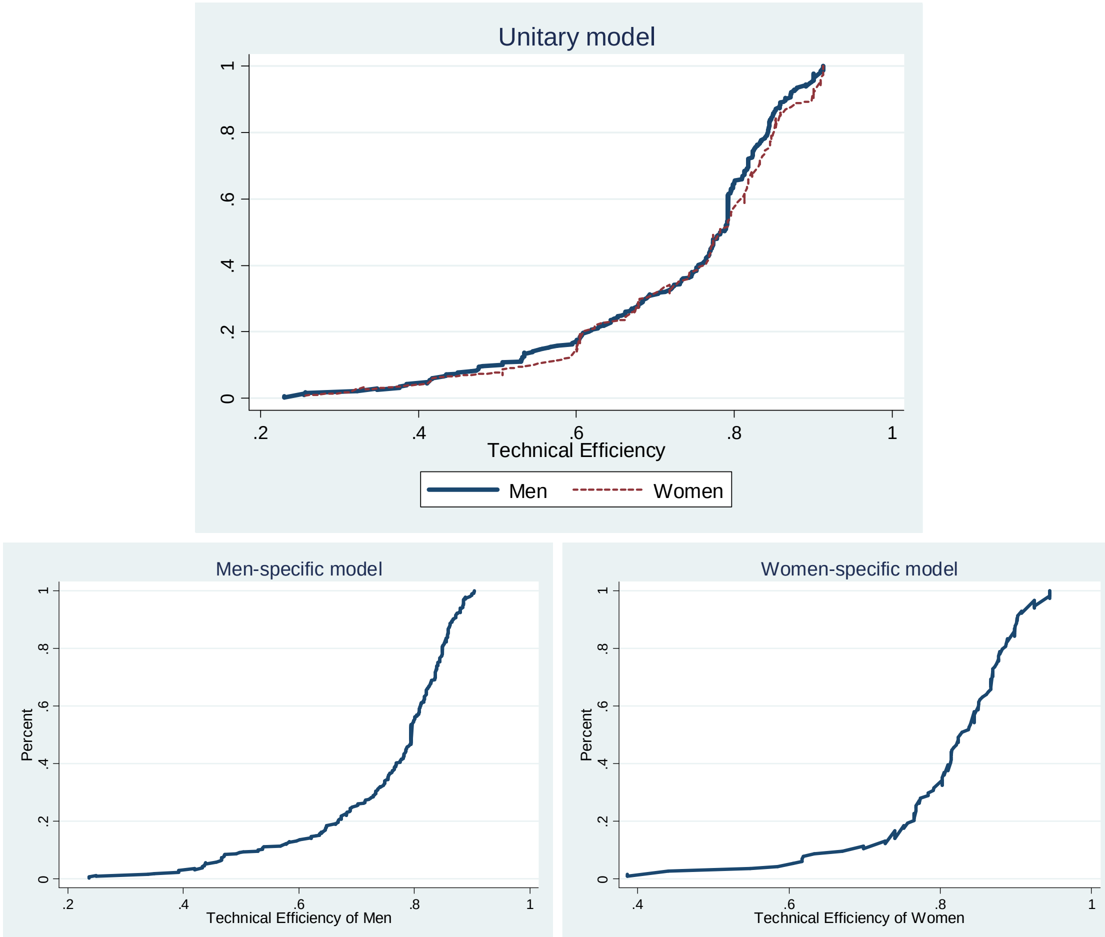


Figure 3.3: Gender comparison of the cumulative distribution of the technical efficiency scores.

3.6.3.2. A gender comparison of technical efficiency by crop

In addition to the comparison of overall crops, it would be interesting to make a comparison by crop. Obviously, although all crops studied are horticultural crops and, more in particular, vegetables destined for the market, the technology use may present some difference from one crop to another and from men to women. Similarly, the managerial capacity and expertise may differ from one crop to another and from female to male plot managers. For these reasons, crop-specific stochastic frontier production functions are estimated, particularly for onion and cabbage, using both unitary and gender-specific models. For tomato, green bean and potato, the comparison cannot be made due to insufficient data. Once again, some difference exists in terms of the magnitude and sign of the coefficients between the unitary and the gender-specific models for both onion and cabbage. Appendix 3.1 presents the crop-specific estimations.

The scores of technical efficiency predicted from the unitary and gender-specific models for onion and cabbage are presented in table 3.5. The predictions of the unitary model differ from the gender-specific models only for onion and particularly for women, while the predictions are similar for cabbage. Based on the unitary model, men and women plot managers achieved the same level of technical efficiency both for onion and cabbage since the differences are not significantly different from zero at the 10% level. These results do not reflect the reality presented by the gender-specific models, particularly for onion. For onion, the gender-specific models show that men achieved a better performance compared to women on their own gender group. Men and women achieved a technical efficiency score that was higher for onion than for cabbage. This implies that women and men exhibit more ability to produce onion than cabbage.

Table 3.5: Gender comparison of technical efficiency scores by crop and by model.

Horticultural Crops		Unitary model			Men-specific model	Women-specific model
		Men and women	Men	Women		
Onion	Mean	0.81	0.81	0.82	0.80	0.75
	Std. Dev.	0.10	0.09	0.10	0.10	0.08
	t-statistic	-0.37 (H0: Men TE – Women TE = 0)				
Cabbage	Mean	0.56	0.55	0.58	0.56	0.58
	Std. Dev.	0.10	0.11	0.10	0.20	0.11
	t-statistic	-1.41				

3.6.4. Determinants of technical inefficiency across gender

As shown in the model of inefficiency (equation 1.7), a set of variables of socio-economic characteristics of plot managers and their household heads (vector Z in equation 1.2 in section 3.3) are used to shed light on the inefficiency effects. The variance inflation factor (VIF) test done showed an absence of multicollinearity between variables indicated by the VIF much lower than 10 for each variable. In addition, variables have been tested such as the share of men's off-farm income and women's off-farm income, suspected to be endogenous due to simultaneity or reverse causality or measurement errors. The performed test of endogeneity of Durbin-Wu-Hausman showed that the residuals predicted from the regressions of the suspected endogenous variables with respect to the other exogenous variables are not significantly correlated with the inefficiency effects at the 10% level, both for the unitary inefficiency model and the gender-specific inefficiency models. Consequently, according to the Durbin-Wu-Hausman test, the variables suspected may be considered as indeed not endogenous (Verbeek, 2008). In doing so, the Ordinary Least Squares (OLS) is consistent and unbiased and is used as estimator. Since the variables hypothesized to have an effect on inefficiency are mostly households characteristics and so are invariant within the household, random effects or fixed effects are not suitable. Table 3.6 presents the OLS estimation of the different inefficiency models. In order to compute robust standard errors and t-statistics, the option robust is used for the estimation.

Table 3.6: OLS estimates for the determinants of technical inefficiency, based on the unitary and gender-specific inefficiency models.

Dependent variable: inefficiency (U)	Unitary inefficiency model		Men-specific inefficiency model		Women-specific inefficiency model	
Explanatory variables	Coef.	Robust Std. Err.	Coef.	Robust Std. Err.	Coef.	Robust Std. Err.
Zone_01 (1=North)	-0.239	0.035***	-0.178	0.040***	-0.142	0.031***
Separate women's plots_01	-0.031	0.035	-0.134	0.028***		
Education_01	-0.012	0.093	0.024	0.087	0.090	0.113
Head's status_01	0.002	0.043			0.134	0.053***
Women's status_01					-0.025	0.025
Age	-0.001	0.001	-0.002	0.001*	0.004	0.001***
Male labour	0.012	0.009	0.024	0.008***	-0.025	0.007***
Female labour	0.002	0.007	0.004	0.007	-0.012	0.012
Credit_01	-0.026	0.031	-0.040	0.033	0.003	0.025
Extension_01	0.038	0.035	0.053	0.030*	0.080	0.114
Log share men's off-farm income	-0.013	0.009	-0.009	0.011	0.006	0.009
Log share women's off-farm income	0.010	0.008	0.006	0.009	-0.017	0.008**
Constant	0.540	0.075***	0.561	0.094***	0.217	0.063***
Number obs F (11, 299) R-squared	311 7.76*** 0.23		230 7.93*** 0.27		81 7.39*** 0.54	

***, **,* significant at the 1%, 5%, and 10% level, respectively.

As can be read from table 3.6, the determinants of technical inefficiency differ greatly from the unitary model to the gender-specific models. We can conclude from the unitary model that the significant determinant of inefficiency effects for both men and women plot managers are the household location or the zone.

Like the unitary model, the men-specific inefficiency model shows that male plot managers' inefficiency is significantly correlated with the location or zone. In addition, the men-specific model shows that men's inefficiency is also significantly related to separate women's plots, the plot manager's age, the male labour used, and access to agricultural extension services. In fact, being a producer in the north zone decreases the inefficiency effects significantly at the 1% level. Plot managers located in the north zone achieve higher efficiency scores compared to those located in the centre and south zones.

Unexpectedly, men's inefficiency effects increase significantly with the male labour used on the plot and their access to extension services. However, without controlling for any household or individual characteristic, the effect of extension services on men's technical inefficiency is negative (-0.06) and significant (P=0.04). This confirms several findings elsewhere, by Jamison and Lau (1982), Ruben (1997), Audibert (1997), Seidu (2008), Chavas et al. (1997), and Alene *et al.* (2008). In fact, the extension services may provide producers with useful advice regarding the choice of adapted seed varieties, depending on the season, the quantity, and the timing of the application of inputs like fertilizers. Above all, extension services may also help the producers to better control plant diseases, by advising them on the adequate pesticide or biological treatment and the required doses.

While in some households, women and men or husband and wives are managing their plots separately, in others, men manage their plots jointly with women. In this latter case, women are not the plot managers but often contribute a lot to the various cropping operations. In joint plots, men are the plot managers and so dispose of the entire output. When women are really interested in horticultural production and want it to become their main source of income, they opt to manage their own plots. The results show that men's inefficiency effects decrease when the men and women within a household are managing their own, separate plots. This negative and significant relationship corroborates the results of the comparison of the technical efficiency scores of men within a household who manage their plots separately and jointly with their wives. The negative effect of separate management on men's inefficiency can be explained by the fact that even when women are managing their separate plots, they still contribute to men's plots, supplying them with their labour force, in particular for time-consuming cropping operations such as transplanting, weeding and harvesting. On the other hand, in households where men manage their plots jointly with their wives, it is not obvious that the wives work as much as when they are managing their separate plots. A moral hazard may arise. In some cases, the wives contribute a lot, but in others, they are busy with their off-farm activities, like small trading. As has been well analyzed by Fafchamps (1998), commitment failure may arise because in case of joint plots, men dispose of the whole output; for this reason, women prefer to divert their time to their own income-generating activities. "Inefficiency is expected to be fostered by factors that exacerbate commitment failure" (Fafchamps, 1998). To attempt to resolve commitment failure, male household heads allocate individual plots and other productive resources (Fafchamps, 1998). The findings show that this solution works in horticultural households in Senegal. There is a gain in efficiency for male heads of household when they allocate separate plots to their wives.

Similarly, inefficiency effects decrease with the age of men plot managers. In other words, the elder male plot managers exhibit a low inefficiency compared to the younger ones. The explanation may be found in the experience they have accumulated. The elder plot managers have gained more experience in horticultural production and, consequently, possess more knowledge and skills to combine the inputs for a better yield. They may also know more about the best seed varieties to use depending on the season. Moreover, their accumulated experience improves their managerial capacity to mobilize the household labour, to plan, and to realize on time the cropping operations (seeding, transplanting, weeding, fertilizing, and plant treatment) which affect the yields. As mentioned by Seidu (2008), rich accumulated experience leads to a greater managerial efficiency and consequently, to a greater technical efficiency.

Furthermore, the women-specific inefficiency model reveals that, like in the men-specific model, inefficiency effects are significantly related (at the 1% level) to the zone, the age of the plot manager, and male labour. In addition, women's inefficiency effects are also significantly connected to their household head status and the share of their off-farm income. Like the men, the women producing in the north zone are more technically efficient than their counterparts of the centre and the south zones. However, contrary to the men-specific model, the women-specific model shows that inefficiency effects increase with age and decrease with male labour. The younger women are more technically efficient. The explanation may be that the younger women have fewer children to care for, which leaves them more time to devote to their production activities and makes them more able of executing their cropping operations on time, with a positive effect on their yield.

Contrary to men's plots, the number of male household members working on women's plots contributes to lessen women's inefficiency effects. In other words, the greater the number of male household members working on women's plots is, the lower are the inefficiency effects. Obviously, with their rich accumulated experience, men's contribution to women's plots can only be useful. In terms of timing and the dosage of inputs application, men know more and are the main decision makers on women's plots. Some cropping operations, like plant treatment, are quite a male speciality. This is another reason why being the female head of a household increases women's inefficiency, as shown by the women-specific model. This result corroborates the results related to the higher technical efficiency scores of wives compared to female heads of household. The results show that women living with their husband head of household are more able to combine their inputs to obtain as much output as possible. Women heads of their own household are in most cases widows. For this reason, they do not have the opportunity to benefit from the technical experience and advice of men. Another reason may be the limited financial means that keep female, widowed heads of household from buying the best varieties of seeds or the required quantity of fertilizer, compared to other women who can benefit from their husband's support. Moreover, female, widowed heads of household may suffer from a shortage of labour, which may prevent them from timely cropping operations like transplanting or weeding, particularly when their children are very young. Fortunately, there is a solidarity network at the community level, which can provide labour support to female, widowed heads of household for some time-consuming cropping operations, although it is usually done with some delay.

Another cause of women's lower inefficiency is the share of women's off-farm income in their total income. The greater the share of women's off-farm income, the lower women plot managers' inefficiency effects are. The explanation may be that women plot managers involved in addition in off-farm income-generating activities, like small trading, may afford to pay for the inputs required for the horticultural production on time, in quantity and in quality.

Women's social status within the household (1=first wife) is negatively related to women's inefficiency effects, but the relationship is not significant at the 10% level. This means that being a first wife did not significantly decrease women's inefficiency effects compared to being a second or third wife.

Altogether, neither men nor women plot managers are fully technically efficient. Several factors explain the technical inefficiency effects. As shown by the gender-specific models, the determinants of technical inefficiency effects vary from male to female plot managers.

3.7. Conclusion and policy implications

This chapter has examined the optimality or allocative efficiency from a household perspective, and the appropriateness of using gender-specific models rather than unitary or pooled models while investigating the economic performance of men and women plot managers within horticultural households in Senegal. This chapter contributes to the gender and economics literature, providing empirical evidence on intra-household resource allocation in a specific social and cultural context, in which polygamy occurs and husband and his wives manage their plots separately.

Women's plots are smaller but more input-intensive per hectare and yield more in terms of output in value per hectare than men's plots do. The examination of the output elasticity shows some differences that are economically important, supporting the suitability of using gender-specific models rather than the unitary model to better capture the gender differential of performance.

Both the unitary model and the gender-specific models' predictions show that women plot managers are as technically efficient as men plot managers are. Moreover, the simulations made indicate that under men's production conditions, women could be as technically efficient as men could be under women's production conditions.

The gender-specific models show that the determinants of technical inefficiency effects present some similarities as well as some differences between men and women plot managers. For both men and women, inefficiency effects are significantly related to location or zone, their age and the male labour used. In addition, men's inefficiency effects decrease when their wives manage their plots separately, while women's inefficiency effects augment with being head of the household and diminish with the share of their off-farm income in their total income.

Furthermore, based on the gender-specific models, the value of the marginal product of land, inputs, labour, and irrigation equipment differs significantly from men's to women' plots within the same household. The value of the marginal product of inputs, household labour, and hired wage labour is higher on men's plots than it is on women's plots, while that of land and irrigation equipment is higher on women's plots than it is on men's plots. Actually, an increase of cropped land by one hundred square meters, holding all other inputs constant, will raise the output by fcfa 21,000 on men's plots and by three times on women's plots. Accordingly, while within a household, land and irrigation equipment are better valued on women's plots, labour and others inputs are better valued on men's plots. Moreover, beyond an intra-household context, neither men nor women plot managers did achieve absolute allocative efficiency, showing their lack of ability to profitably combine inputs in such a way as to equalize the value of their marginal products to their unit prices.

From all these findings, we can conclude that optimality or allocative efficiency from a household perspective that corresponds to the situation under which an equality occurs of the value of the marginal product of the inputs between men's and women's plots within a household, is far from being achieved. With regard to the allocation of land, inputs, labour, and capital irrigation equipment, for instance, some improvements can be made between men's and women's plots, allowing for the value of the marginal product. The findings imply that a shift of labour and inputs from women's plots to men's plots and a shift of land and capital irrigation equipment from men's plots to women's plots will lead to more output in value per hectare for the household. Moreover, neither men nor women are allocatively efficient with respect to land; they both need to scale up their cropped land.

In terms of policy implications, in spite of having accumulated a rich experience, the horticultural households are still not fully technically or allocatively efficient. Policy makers need to develop new efforts to provide horticultural households with suitable support that will improve their ability to manage their productive resources more efficiently. This requires research institutes and extension services to be more operational, working closely with the horticultural households. As shown by the findings, access to extension services decreases the inefficiency effects by 0.06. Horticultural production is labour–intensive; particularly the irrigation operation is really time-consuming. Thus, it will be useful to improve the technology of production through a sustainable system of credit, which will allow farmers to modernize their production. For instance, making accessible the use of improved irrigation equipment will lead to an increase of the scale of production, with a positive effect on both productivity and efficiency.

However, this policy should be gender–sensitive, taking into account the specific problems faced by female plot managers. A better access to land and to improved irrigation equipment will be a lever to improve women’s economic performance and, consequently, their well-being and the whole household’s welfare. Obviously, horticulture is not the only potentially good source of poverty alleviation, but it contributes a lot to the agricultural sector and economy. As a consequence, more attention should be paid to it.

Appendix 3.1.

From the unitary model can be deduced that, except irrigation equipment cost, all the other explanatory variables have a positive and significant effect on the onion output in value per hectare at the 5% level. The variable gender is positive and not significant at the 10% level. The men-specific model shows that only the variable plot area and cost of input influences positively and significantly at the 5% level the output in value per hectare of onion. Contrary, for women plot managers, the output of onion in value per hectare is significantly and positively related to input and hired labour at the 10% level. The hypothesis of a constant return to scale is rejected for the unitary and men-specific model and accepted for the women-specific model. The likelihood ratio test shows that, for onion, the estimates of the unitary stochastic frontier production function differ significantly from gender-specific ones at the 1% level (table A 3.1).

Table A 3.1: Estimates of the parameters of the unitary and gender-specific stochastic frontier production functions for onion.

Dependent variable log output in value per ha: log(Q)	**Onion**					
	Unitary model		Men-specific model		Women-specific model	
Explanatory variables	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Log(Plot)	0.748	0.319***	0.638	0.333**	-0.498	4.727
Log(Input)	0.295	0.093***	0.456	0.116***	0.314	0.182*
Log(Labh)	0.079	0.034**	0.047	0.040	0.114	0.130
Log(Labo)	0.038	0.015***	0.026	0.017	0.050	0.030*
Log(Irreq)	0.030	0.051	-0.047	0.056	-0.007	0.134
Gender (1=woman)	0.042	0.101				
Seas_01						
Constant	10.176	1.112***	9.539	1.362***	10.244	2.998***
σ^2	1.370		0.585		0.151	
$\gamma = \sigma_u^2/\sigma^2$	0.885		0.759		0.284	
σ_u^2	1.213		0.445		0.042	
σ_v^2	0.156		0.140		0.108	
Log likelihood	-97.53		-69.18		-17.74	
Nb. Obs. (plots)	149		105		39	
Nb. Group (household)	80		74		29	
Obs. per group: Min	1		1		1	
Avg	1.9		1.4		1.3	
Max	7		4		4	
Wald chi2(6-5)	36.32***		23.17***		13.91***	
Wald chi2(1) H0:CRT	5.47***		3.66**		0.01	
Likelihood-ratio test: LR chi2(8)	21.22***					

***, ** significant at the 1% and 5% levels, respectively.

Table A 3.2 presents the unitary and gender-specific stochastic frontier production functions estimated for cabbage. For the men-specific model, as the number of groups or households is almost equal to the number of plots, which means no household fixed effects, the ML for cross-sectional and panel data could not be used. The ML for non-sectional data was used for the estimation.

Table A 3.2: Estimates of the parameters of the unitary and gender-specific stochastic frontier production functions for cabbage.

Dependent variable log output in value per ha: log(Q)	**Cabbage**					
	Unitary model		Men-specific model		Women-specific model	
Explanatory variables	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Log(Plot)	-0.568	0.360	-0.787	0.374**	1.106	0.930
Log(Input)	0.146	0.084*	0.108	0.135	0.181	0.117
Log(Labh)	-0.008	0.048	0.044	0.064	0.012	0.114
Log(Labo)	-0.009	0.018	-0.009	0.026	-0.012	0.025
Log(Irreq)	0.080	0.053	-0.033	0.076	0.128	0.080*
Seas_01	-0.160	0.134	-0.098	0.178	-0.572	0.304*
Gender (1=female)	0.056	0.101				
Constant	13.095	1.412***	13.594	1.447***	12.332	14.335
σ^2	0.202		0.824		0.140	
$\gamma = \sigma_u^2/\sigma^2$	0.336				0.382	
σ_u^2	0.068				0.053	
σ_v^2	0.134				0.086	
Log likelihood	-75.76		-78.36		-15.06	
Nb. Obs. (plots)	126		92		36	
Nb. Group (household)	94		92		28	
Obs. per group: Min	1		1		1	
Avg	1.3		1		1.3	
Max	5		1		3	
Wald chi2(7-6)	24.77***		14.22**		19.41***	

***, **, * significant at the 1%, 5%, and 10% levels, respectively.

Chapter 4.

Households Profit Optimization and the Efficiency of Labour Contract Choice

4.1. Introduction

In Senegal, like in most African countries, horticultural households’ production systems are highly labour-intensive with a low capital input. The area of land that a household can crop out of the owned land is mainly conditional on the availability of labour. While some households can rely only on their household labour, others take recourse to hired labour. This hired labour can be based on a sharecropping contract or on a wage contract.

Sharecropping is a form of tenancy based on an agreement between the landowner and the tenant in terms of input contribution and output sharing. Sharecropping has a long, worldwide history, but the types of agreement between landowner and tenant vary from one location to another. In Senegal, for instance, sharecropping is chiefly used on horticultural crops that are cash crops. The agreement is informal, verbal, and hence not written down; it is only witnessed by a third party, who can be a parent or a friend of the landowner, or the head of the village. The agreement is for one horticultural season and is generally based on the share in two equal parts of the profit of production. One part is for the sharecropper, who provides the labour force and expertise required for the production. The other part is for the landowner, who provides to the sharecropper the land plot as well as all the required inputs (seeds, organic and mineral fertilizers, pesticides, fuel) and some facilities, such as housing, feeding, and occasionally health care.

For hired wage labour, on the other hand, the landowner pays a fixed wage to the worker. Usually, the wage is paid at the end of the cropping season rather than monthly, in agreement with the worker. The landowner usually provides the same facilities to the hired wage workers as is the case in sharecropping contracts, particularly when they come from far away.

More and more land tenancy based on fixed rent is less observed in Senegal. On the one hand, only very rarely are households willing to rent out their land because they fear to lose their land rights, due to the land law providing the right to continued occupancy to the person who cultivates the land for a couple of consecutive years. On the other hand, the tenants are generally not only landless, but they also are so poor that they lack the financial means that would enable them to rent in land and to provide the inputs required for the production. Both for the households’ landlord and the landless tenants, who have a limited liability, contracting based on sharecropping and wage are the remaining alternatives. A household's choice between these two labour contracts varies in general, depending on the plot size cropped and the level of the irrigation equipment. The reasons behind the labour contract choice need to be further investigated. While several theoretical and empirical studies have provided valuable information about land tenancy, comparing sharecropping to a fixed rent, very few studies have scrutinized the choice between a sharecropping and a wage labour contract, in particular in Africa and in a context of modernization of the agricultural production systems.

Are the contracts with hired labour, either as sharecroppers or as wage labourers, comparable to household labour in terms of household profit optimization? At the plot level, controlling for irrigation equipment, did the household make the efficient labour contract choice, the choice that provides a higher optimum profit? Did the household use inputs efficiently across labour contract? This chapter tries to answer these research questions through an in-depth investigation of plot-level profit optimization over the labour arrangement made. Therefore, after a survey of the literature on land tenancy and the specification of the theoretical and empirical models, this chapter will focus on a comparative analysis of household profit optimization across plots under household labour, a sharecropping labour contact, or a wage labour contract. Then, the chapter will provide evidence on the efficiency of the labour contract choice and the inputs used at plot level. From the results, a conclusion will be drawn with some policy implications.

4.2. A literature review on land tenancy

In agriculture, a broad assortment of land tenancy forms is practised worldwide. While some land lease arrangements are based on sharecropping and a fixed rental, others are in the form of wage labour. In fixed rental tenancy, the tenant pays a fixed rent to the landowner, provides all inputs and earns the entire output. In share tenancy or sharecropping, the landlord provides the land plot and agrees with the tenant the terms of the share of input costs and output, depending on the location. These land or labour contracts can be seen as suitable strategies, developed to equate land-man ratios over households with different, relative endowments of land and labour.

Many empirical studies have examined the reasons behind the existence and the continuation of sharecropping and its social, economic, and policy implications, especially in Asia and, to a lesser extent, in Africa (Stiglitz, 1989; Ray 1998; Ghatak and Pandey, 2000; Garrett and Xu, 2003; Otsuka and Hayami, 1988; Ahmed *et al.*, 2002; Pender *et al.*, 2002; Benin *et al.,* 2005; Reiersen, 2001; Araujo and Bonjean, 1999; Canjels, 1996). Despite numerous studies done, land tenancy still remains an attractive subject of research, as shown by several recent publications by Ahmed *et al.* (2002), Benin *et al.* (2005), Tesfay (2006), Kassie and Holden (2007), Holden (2007), and Braido (2008).

The existing theories of sharecropping were subject to critical reviews in terms of the general theory of agency or principal-agent relations. The advantage of sharecropping was associated with its savings in transaction costs, but also with risk sharing (Stiglitz, 1989). As supervision costs are part of the transaction costs, obviously, a wage labour contract may involve higher transaction costs than sharecropping does (Eswaren and Kotwal, 1985). The supervision of the work effort of wage labour is more costly than that pertaining to sharecroppers (Ahmed *et al*., 2002). Otsuka and Hayami (1988) have emphasised the importance of supervision and other forms of transaction costs for the use of hired wage labour. While in a wage labour contract, the supervision is undertaken by the landlord and in a fixed rental contract by the tenant, in a sharecropping contract, both tenant and landlord have incentives to self-supervise so as to mitigate any moral hazard behaviour (Eswaren and Kotwal, 1985). The supervision time spent by the household’s landlord to prevent hired workers from cheating is an important part of the labour input, particularly in a wage labour contract. The supervision costs evaluated at the household’s off-farm wage rate may have an impact on the profitability and the efficiency of the labour contract choice to make. This research intends to provide theoretical and empirical evidence on this impact.

Under uncertain circumstances, the existence of sharecropping can be justified by its role in risk sharing with and without any enforcement, as long as both landlord and tenant are risk-averse (Ahmed *et al*., 2002). While in a fixed rental arrangement, the tenant bears the entire risk linked to the production, in a wage labour contract, it is the landlord who bears the whole risk, and in a sharecropping contract, it is both the landlord and the tenant who share the risk. As demonstrated theoretically (Ray, 1998), a sharecropping contract lowers the return to the tenant in a good state and raises it in a bad state, comparatively to a fixed rent. Benin *et al.* (2005) have found that factors increasing the production risk are in favour of sharecropping or risk-pooling arrangements, while factors reducing the risk tend to shift land tenancy away from sharecropping and in favour of fixed rent leases. All recent models, including that of Pender and Fafchamps (2000), incorporate some degree of risk sharing between landlord and tenant. Sharecropping is viewed in the literature as a constrained efficient tenancy, which balances incentives and risk sharing (Braido, 2008).

According to the Marshallian argument supported by several authors, share tenancy is inefficient because the tenant receives only a share of his own marginal product of labour as marginal revenue. Contrary to this standard opinion that criticized sharecropping because it is inefficient and dampens incentives and productivity, according to Stiglitz (1989), Ray (1998), Ghatak and Pandey (2000), and Garrett and Xu (2003), sharecropping is desirable because it increases incentives, particularly compared to a wage labour contract. Benin *et al.* (2005), Tesfay (2006), Braido (2008) and others have provided empirical evidence that challenges the conventional wisdom connecting sharecropping to disincentives. In particular with regard to sharecropping in a Senegalese context, in which the landlord provides all the inputs, the tenant actually would have incentives to work hard in order to maximize his profit, especially in case he does not have any other alternative off-farm work or can only work at a low wage rate. It has been demonstrated that the Marshallian inefficiency implied in many of the share tenancy models (Binswanger *et al.*, 1995; Otsuka and Hayami, 1988; Ahmed *et al.*, 2002; Pender *et al.*, 2002; Reiersen, 2001; and Araujo and Bonjean, 1999) was a consequence of a partial or incomplete analysis, in which the optimizing behaviour of landlords was neglected, the characteristics of tenants and plots were not taken into account, or the range of contract choice was very limited (Otsuka and Hayami, 1988). For instance, in Senegal, while the landlords have enough land but suffer from a labour shortage, the sharecroppers or tenants are landless because they come from other, dry areas, which are inappropriate for any horticultural production.

Moreover, if the landlord does not have at his/her disposal any information about the tenant's work ability, the landlord would prefer a contract based on a fixed rent rather than on sharecropping. At the tenant's side, if the tenant has the opportunity to make a contract choice, the tenant with a high work ability would opt for a fixed rent in order to get his entire marginal product, while the tenant with a low work ability would choose sharecropping (Ray, 1998) or a wage contract. This screening theory may somewhat explain the reason for the coexistence of sharecropping with other forms of land tenancy (Ray, 1998).

Another major research agenda is to identify the technological, economic, and institutional conditions leading to different choices of land tenancy. As mentioned by Otsuka and Hayami (1988), it is evident that no contractual form is universally efficient, and it is not relevant to discuss in abstract terms whether sharecropping and wage labour contracts are efficient or not. Sharecropping and wage labour contracts can be efficient in specific technical, institutional, and socioeconomic environments and can be inefficient in others. Both the sources of efficiency or inefficiency and the mechanism of contract choice need to be further examined through in-depth investigations into the agricultural production technology, the agrarian community structure, and market conditions (Otsuka and Hayami, 1988; Ray, 1998; Ghatak *et al.*, 2000). This shows the scientific relevance of this study, which intends to contribute to this research agenda by analysing at plot level the efficiency of the labour contract choice made.

Altogether, the review of the literature shows that, so far, the coexistence of the different forms of land tenancy or labour contract have been explained by different theories relative to Marshallian inefficiency, incentives, transaction costs, including the supervision costs of labour, moral hazard, risk sharing, screening, and eviction. These theories and the empirical evidence have greatly contributed to explain the reasons behind land tenancy or labour contract choice. This study follows up on this and also intends to take a further step, by focusing particularly on the production technologies at plot level and by making thorough use of a theoretical model based on household profit optimization, to compare the optimum profit derived from plots based on household labour, a sharecropping labour contract, or a wage labour contract. This chapter does not take risk behaviour into account, which we will deal with in the next chapter, but focuses mainly on supervision costs. This chapter therefore attempts to find out to what extent the supervision rate and the opportunity wages ratios of the landlord, the sharecropper, and the wage worker may determine the efficiency of the labour contract based on household profit optimization. In order to test this efficiency of the labour contract choice, for each plot, simulations were made to see whether another labour contract than presently applied would have yielded a higher profit to household. In doing so, this research makes a scientific contribution to the theory of land tenancy, providing theoretical and empirical evidence on household profit optimization across labour contract, by using data from the Niayes Zone in Senegal.

4.3. The theory

For a better understanding of the land or labour tenancy theory, diagram 4.1 is designed to determine for a given plot of land the optimum labour supplied by workers hired under a sharecropping contract and a wage contract, in a context of mechanization of the production. Although the production is carried out under risky or uncertain circumstances, for simplicity's sake, we did not take into account the risk attitude of the landowner and the worker, which will be dealt with in the next chapter.

Let us consider the case of horticulture in Senegal, where some households still use manual irrigation with buckets and ropes to fetch water from the wells and irrigate the plots, while others are mechanizing their production by using labour-saving irrigation equipment like a motor pump. The labour market is not competitive. Besides farming, the sharecroppers may do off-farm work. In the labour market, they may find a wage rate W_o much lower than the wage rate W_h, paid by the household landowner to hired wage workers, including supervision costs. The household landowner does not have any off-farm work that requires him to hire labour at wage W_o, so he only hires for farm work. For a given profit share rate β, usually equal to 1/2, the sharecroppers will supply labour up to equalizing their share of the marginal product of labour ($\beta Y'$) to their off-farm opportunity wage rate (W_o). In a wage contract, the landowner will equalize at the optimum the marginal product of hired wage workers (Y') to the wage rate W_h, including supervision costs.

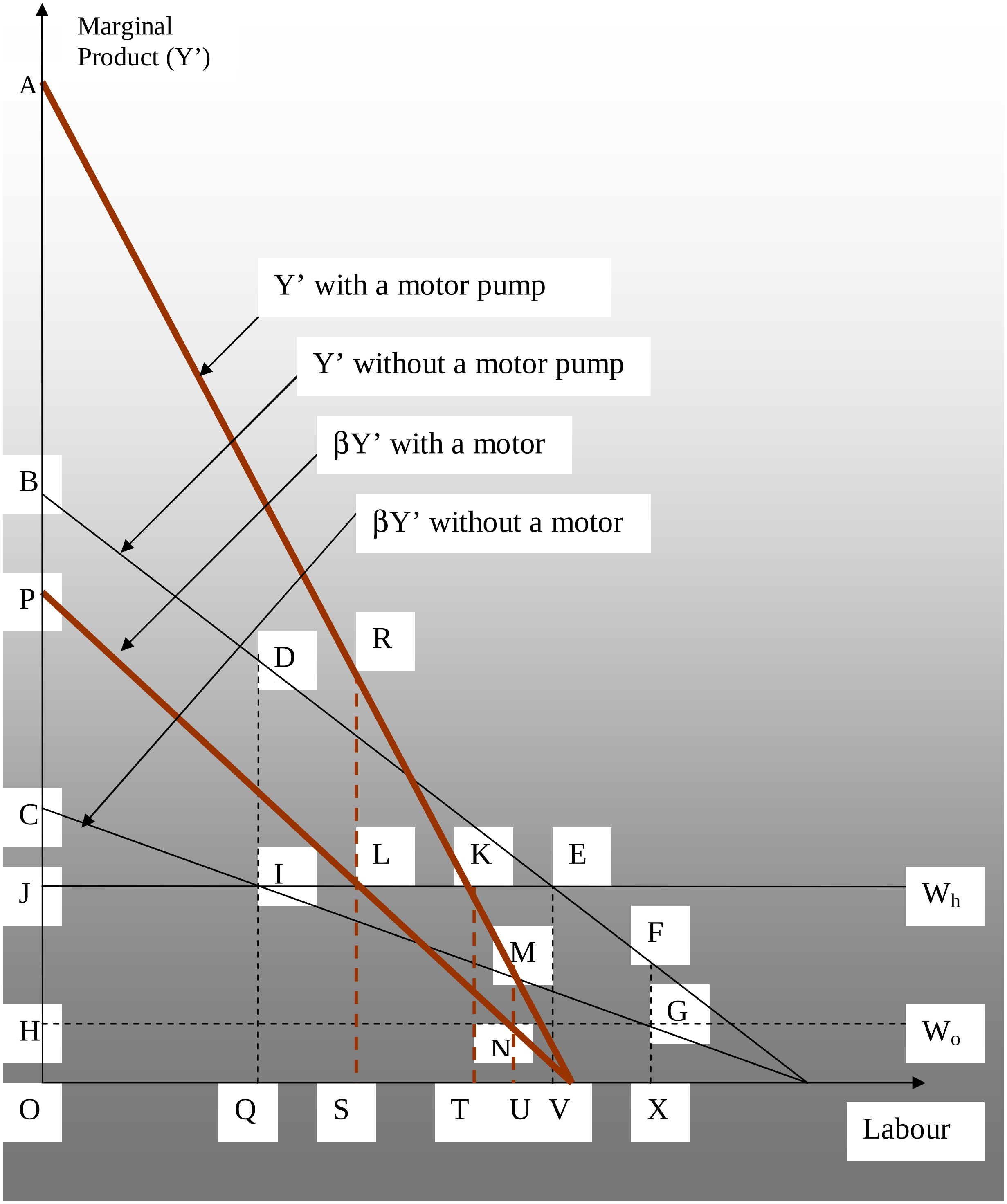


Figure 4.1: Diagrammatic presentation of the model of labour contract choice over mechanization of the production.

In figure 4.1, sharecroppers' optimum labour is established at point G on plots without a motor pump and at point N on plots with a motor pump, while hired wage workers are employed at points E and K, respectively, on plots without and with a motor pump. Both on plots without and with a motor pump, the optimum labour supplied by sharecroppers is higher than that of hired wage workers is. Because of the few possibilities of off-farm work and the low off-farm opportunity wage, sharecroppers do have incentives to work hard on the farm. Usually, the sharecroppers have to be on the field all day. On plots without a motor pump, as can be seen from diagram 4.1, the surplus the household landowner receives from plots under a sharecropping contact (area BFGC) is higher than that from plots under a hired wage labour contract (area BEJ). Consequently, on plots without a motor pump, the household landowner may prefer to hire labour based on a sharecropping contract rather than a wage contract, to earn more profit. By allocating the same amount of optimum labour to off-farm opportunity employment at wage rate W_o, sharecroppers will earn less (area HGXO) than they will earn from farming (area CGXO). This means that, for the worker, sharecropping would be preferable to off-farm work. At the wage rate paid by a household, including supervision costs W_h, a sharecropping contract provides more profit (area CGXO) to the worker than a wage contract does (area JEVO). Thus, the worker would prefer to be hired under a sharecropping rather than under a wage contract. Consequently, on plots without a motor pump, sharecropping is in the interest of both landowner and worker. Without a motor pump, in other words, sharecropping is a feasible contract.

The entire discussion is based on an assumption with respect to the slopes of the curves without and with a motor pump. The curve with a motor pump is steeper than that without a motor pump. Actually, with the use of a motor pump, the marginal product of labour rises because irrigation becomes less time-consuming and, consequently, the working time decreases. On plots under hired wage labour, the household spends time to supervise the workers to prevent them from cheating. Thus, the supervision cost is an important transaction cost to include in the wage. On plots with a motor pump, the surplus the household realizes on plots under a wage contract (area AKJ) is much higher than it is on plots under a sharecropping contract (area AMNP). This means that, when a motor pump is used, the household's preference would be to hire labour under a wage contract rather than under a sharecropping contract. Sharecroppers could win the contract only if they would bid money for becoming a sharecropper at a plot with a motor pump, or if they would settle for a lower share.

To sum up: on plots without a motor pump, when the off-farm opportunity wage of workers is much lower than the farm wage rate paid, supervision costs included, the household landowner would opt to hire labour under a sharecropping contract rather than under a wage contract because the surplus is higher. However, on plots with a motor pump, the household landowner's surplus is higher under a wage contract rather than under a sharecropping contract. Consequently, with the mechanization of the production, the household would go for hiring labour under a wage contract than under sharecropping. The worker earns more under sharecropping than under wage labour, both with and without a motor pump.

If the labour market was competitive in such a way that the sharecroppers opportunity wage W_o would equal wage W_h, paid by the household and with supervision costs included, both on plots with and without a motor pump, the household landowner would prefer to hire labour under a wage contract rather than under a sharecropping contract. The reason is that the surplus from a wage contract (areas BEJ and AKJ, respectively, without and with a motor pump) is higher than that from sharecropping (areas BDIC and ARLP, respectively, without and with a motor pump). For the worker, the preference would be a wage contract on plots without a motor pump (area JEVO > area CIQO) and sharecropping on plots with a motor pump (area JKTO < area PLSO).

4.4. Household modelling and labour

Horticultural production is highly labour-demanding. In Senegal, for most households, household labour is not sufficient to crop all the land owned. Instead of leaving the land idle or renting it out, households try to use the area of land as much as possible. Therefore, many households take recourse to hired labour, some based on sharecropping contracts, while others prefer to hire labour based on wage contracts. What are the reasons behind these labour contract choices? Observations show that households that have large size farms and more advanced irrigation equipment are likely to opt for hired wage labour. Households with a medium size farm with relatively less irrigation equipment opt for sharecropping. Households with small farms and less equipment have a tendency to limit themselves to their own household labour.

Let us consider the problem faced by the household of allocating labour and non-labour inputs to a given plot of land. We denote the opportunity cost or wage of household labour by w_e, of sharecroppers by w_o, and of hired workers by w.

Household labour

Accordingly, in case the household uses only household labour L_h, the profit maximization problem can be specified as:

$$\text{Max } \pi_h = p_y Y(L_h, X_h) - p_x X_h + w_e L_e \qquad (4.1)$$

with respect to L_h and X_h.

subject to :

- a time constraint: $L = L_e + L_h$ (4.2)
- a production constraint: $Y_h = C L_h^{\lambda} X_h^{\gamma}$

If we specify the production function to be Cobb-Douglas, land-fixed and $\lambda + \gamma < 1$, we have

$$\text{Max } \pi_h = p_y C L_h^{\lambda} X_h^{\gamma} - p_x X_h + w_e (L - L_h) \qquad (4.3)$$

First-order conditions (FOC) with respect to L_h, the total household labour used on the plot,

$$\begin{aligned} &\frac{\partial \pi_h}{\partial L_h} = 0 \Leftrightarrow p_y \lambda C L_h^{\lambda-1} X_h^{\gamma} - w_e = 0 \\ &\Leftrightarrow L_h^{*} = \frac{p_y \lambda Y_h}{w_e} \end{aligned} \qquad (4.4)$$

and with respect to X_h, the total inputs used on the plot:

$$\frac{\partial \pi_h}{\partial X_h} = 0 \Leftrightarrow p_y \gamma C L_h{}^{\lambda} X_h{}^{\gamma-1} - p_x = 0$$
$$\Leftrightarrow X_h{}^{*} = \frac{p_y \gamma Y_h}{p_x} \qquad (4.5)$$

Knowing L_h^*, the optimum household labour, and X_h^*, the optimum input, we can derive Y_h^*, the optimum production to supply by household to maximize profit:

$$Y_h = C L_h{}^{*\lambda} X_h{}^{*\gamma}$$
$$\Leftrightarrow Y_h = C\left(\frac{\lambda p_y Y_h}{w_e}\right)^{\lambda}\left(\frac{\gamma p_y Y_h}{p_x}\right)^{\gamma} \qquad (4.6)$$
$$\Leftrightarrow Y_h{}^{*} = C^{\frac{1}{1-\lambda-\gamma}}\left(\frac{\lambda}{w_e}\right)^{\frac{\lambda}{1-\lambda-\gamma}}\left(\frac{\gamma}{p_x}\right)^{\frac{\gamma}{1-\lambda-\gamma}} p_y^{\frac{\lambda+\gamma}{1-\lambda-\gamma}}$$

The optimum household labour L_h^* and input X_h^* can be expressed as follows, as a function of prices and wage:

$$L_h{}^{*} = C^{\frac{1}{1-\lambda-\gamma}}\left(\frac{\lambda}{w_e}\right)^{\frac{1-\gamma}{1-\lambda-\gamma}}\left(\frac{\gamma}{p_x}\right)^{\frac{\gamma}{1-\lambda-\gamma}} p_y^{\frac{1}{1-\lambda-\gamma}}$$
$$X_h{}^{*} = C^{\frac{1}{1-\lambda-\gamma}}\left(\frac{\lambda}{w_e}\right)^{\frac{\lambda}{1-\lambda-\gamma}}\left(\frac{\gamma}{p_x}\right)^{\frac{1-\lambda}{1-\lambda-\gamma}} p_y^{\frac{1}{1-\lambda-\gamma}} \qquad (4.7)$$

Hired wage labour under supervision

If the household opts to hire labour based on a wage contract L_w at wage w, we assume that for each unit of wage labour, σ units of supervision by the household are needed, at a wage rate of household off-farm work w_e. This is the household's labour opportunity cost of supervising wage labour instead of doing off-farm work. When the household opts for hiring labour based on a wage contract, the profit maximization problem is:

Max $\pi_w = p_y Y(L_w, X_w) - p_x X_w - wL_w - \sigma w_e L_w$ (4.8) subject to production constraint: $Y_w = CL_w{}^{\lambda} X_w{}^{\gamma}$ (4.9)

Max $\pi_w = p_y CL_w{}^{\lambda} X_w{}^{\gamma} - p_x X_w - L_w(w + \sigma w_e)$

This leads to the following expressions for optimal production and inputs:

$$Y_w^* = C^{\frac{1}{1-\lambda-\gamma}} \left(\frac{\lambda}{w + \sigma w_e} \right)^{\frac{\lambda}{1-\lambda-\gamma}} \left(\frac{\gamma}{p_x} \right)^{\frac{\gamma}{1-\lambda-\gamma}} p_y{}^{\frac{\lambda+\gamma}{1-\lambda-\gamma}} \qquad (4.10)$$

$$L_w^* = C^{\frac{1}{1-\lambda-\gamma}} \left(\frac{\lambda}{w + \sigma w_e} \right)^{\frac{1-\gamma}{1-\lambda-\gamma}} \left(\frac{\gamma}{p_x} \right)^{\frac{\gamma}{1-\lambda-\gamma}} p_y{}^{\frac{1}{1-\lambda-\gamma}}$$

$$X_w^* = C^{\frac{1}{1-\lambda-\gamma}} \left(\frac{\lambda}{w + \sigma w_e} \right)^{\frac{\lambda}{1-\lambda-\gamma}} \left(\frac{\gamma}{p_x} \right)^{\frac{1-\lambda}{1-\lambda-\gamma}} p_y{}^{\frac{1}{1-\lambda-\gamma}}$$

Compared with the first case of using household labour only, we see that the production and use of inputs are lower if $w+\sigma w_e$ is greater than w_e.

Sharecropping labour

Instead of hiring labour based on a wage contract, a household may opt to hire labour based on a sharecropping contract. In Senegal, under the usual sharecropping contract, the landlord pays for all the inputs. These inputs are deducted from the revenue, to obtain the profit that is shared between the landlord and the tenant. The usual share is 50%-50%, but to generalize, the share of profit received by the tenant is set to β and that received by the landlord to 1-β.

From a total labour endowment L_t, the tenant or worker can allocate labour L_s to sharecropping and L_o to alternative sources of off-farm work at wage w_o. So, the tenant's profit maximizing problem is:

Max $\pi_{st} = \beta[p_y Y(L_s, X_s) - p_x X_s] + w_o L_o$ (4.11) subject to :

- a production constraint: $Y_s = C.L_s^{\lambda} X_s^{\gamma}$ (4.12)
- a time constraint: $L_t = L_s + L_o$

FOC :

$$\frac{\partial \pi_{st}}{\partial L_s} = 0 \Leftrightarrow \beta p_y \lambda C L_s^{\lambda-1} X_s^{\gamma} - w_o = 0$$

$$\Leftrightarrow L_s^{*} = \left(\frac{w_o X_s^{-\gamma}}{\beta p_y \lambda C} \right)^{\frac{1}{\lambda-1}} \qquad (4.13)$$

Knowing the optimum sharecropping labour L_s^{*}, the optimum production Y_s^{*} can be deduced:

$$Y_s^{*} = C \left(\frac{w_o X_s^{-\gamma}}{\beta p_y \lambda C} \right)^{\frac{\lambda}{\lambda-1}} X_s^{\gamma} \qquad (4.14)$$

The household's profit maximization problem when opting for a sharecropping labour contract is:

Max $\pi_s = (1-\beta)[p_y Y_s^{*}(L_s^{*}, X_s) - p_x X_s]$ (4.15)

with respect to X_s, and with

$$Y_s^{*} = C \left(\frac{w_o X_s^{-\gamma}}{\beta p_y \lambda C} \right)^{\frac{\lambda}{\lambda-1}} X_s^{\gamma}$$

or

$$Max\pi_s = (1-\beta)\left[p_y C\left(\frac{w_o X_s^{-\gamma}}{\beta p_y \lambda C}\right)^{\frac{\lambda}{\lambda-1}} X_s^{\gamma} - p_x X_s\right]$$

$$\Leftrightarrow Max\pi_s = (1-\beta)\left[p_y C\left(\frac{w_o}{\beta p_y \lambda C}\right)^{\frac{\lambda}{\lambda-1}} X_s^{\frac{-\gamma}{\lambda-1}} - p_x X_s\right]$$

FOC with respect to X_s, the total inputs used on a sharecropped plot:

$$\frac{\partial \pi_s}{\partial X_s} = 0 \Leftrightarrow (1-\beta)\left[p_y C\left(\frac{w_o}{\beta p_y \lambda C}\right)^{\frac{\lambda}{\lambda-1}}\left(\frac{-\gamma}{\lambda-1}\right) X_s^{\frac{1-\lambda-\gamma}{\lambda-1}} - p_x\right] = 0$$

$$\Leftrightarrow X_s^* = C^{\frac{1}{1-\lambda-\gamma}}\left(\frac{\beta\lambda}{w_o}\right)^{\frac{\lambda}{1-\lambda-\gamma}}\left(\frac{\gamma}{(1-\lambda)p_x}\right)^{\frac{1-\lambda}{1-\lambda-\gamma}} p_y^{\frac{1}{1-\lambda-\gamma}} \tag{4.16}$$

Knowing the optimum X_s^* , the optimum sharecropping labour L_s^* can be expressed as follows as a function of prices and wage:

$$\Leftrightarrow L_s^* = C^{\frac{1}{1-\lambda-\gamma}}\left(\frac{\beta\lambda}{w_o}\right)^{\frac{1-\gamma}{1-\lambda-\gamma}}\left(\frac{\gamma}{(1-\lambda)p_x}\right)^{\frac{\gamma}{1-\lambda-\gamma}} p_y^{\frac{1}{1-\lambda-\gamma}} \tag{4.17}$$

and the optimal production is

$$Y_s^* = C^{\frac{1}{1-\lambda-\gamma}}\left(\frac{\beta\lambda}{w_o}\right)^{\frac{\lambda}{1-\lambda-\gamma}}\left(\frac{\gamma}{(1-\lambda)p_x}\right)^{\frac{\gamma}{1-\lambda-\gamma}} p_y^{\frac{\lambda+\gamma}{1-\lambda-\gamma}} \tag{4.18}$$

Knowing the optimum production, the optimum labour and the optimum inputs, the maximum profits for the household can be deduced and expressed as follows as a function of prices and wage:

- on plots based on household labour,

$$\pi_h^* = p_y Y_h^* (1-\lambda-\gamma) \tag{4.19}$$

- on plots based on a wage labour contract:

$$\pi_w^* = p_y Y_w^* (1-\lambda-\gamma) \tag{4.20}$$

- on plots based on a sharecropping contract:

$$\pi_s^* = (1-\beta) p_y Y_s^* (1-\frac{\gamma}{1-\lambda}) \tag{4.21}$$

The choice between the three land tenancy regimes is based on which profitability is higher: π_h^* *or* π_s^* *or* π_w^*.

At the given plot size, the household prefers sharecropping over using hired wage workers if

$$\pi_s^* = (1-\beta) p_y Y_s^* (1-\frac{\gamma}{1-\lambda}) > \pi_w^* = p_y Y_w^* (1-\lambda-\gamma) \tag{4.22}$$

Or the profit ratio R

$$\begin{aligned} &R = \frac{\pi_s^*}{\pi_w^*} > 1 \\ &\Leftrightarrow (1-\beta)\beta^{\frac{\lambda}{1-\lambda-\gamma}}(1-\lambda)^{\frac{\lambda-1}{1-\lambda-\gamma}}(\frac{w_0}{w_h})^{\frac{-\lambda}{1-\lambda-\gamma}} > 1 \end{aligned} \tag{4.23}$$

Here, w_h may include supervision costs ($w_h = w + \sigma w_e$). For σ=0 (no supervision), $w_h = w$ and if $w_o = w = w_h$, i.e. the sharecropper could also work as a hired worker. This is the case if the profit ratio denoted R_0:

$$R_0 = \frac{(1-\beta)}{(1-\lambda)}\left(\frac{\beta^{\lambda}}{(1-\lambda)^{\gamma}}\right)^{\frac{1}{1-\lambda-\gamma}} > 1 \tag{4.24}$$

For β=0.5, this will not be the case for values of λ and γ that sum to less than 1. Figure 4.2 shows the values of the profit ratio R_0 for γ=0.1 and varying values of λ. It also shows the values of the wage ratio w_o / w_h at which the profit ratio R is equal to one (equation 4.23).

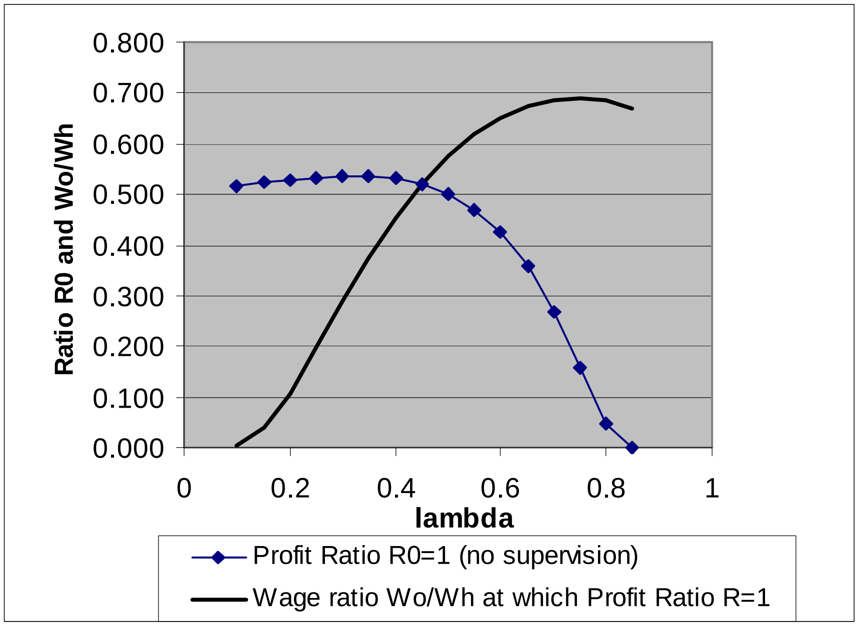


Figure 4.2: Values of the profit ratio R_0 (no supervision and the sharecropping opportunity wage equals the wage paid by the household: σ=0 and $w_o = w = w_h$), and values of the wage ratio $\frac{w_o}{w_h}$ (opportunity cost of sharecropper / wage including supervision cost) at which the profit ratio R ($\frac{\pi_S^*}{\pi_w^*}$) is equal to one for γ=0.1 and varying values of λ.

Hence, sharecropping would be preferred only if the wages are not equal. If the profit ratio R_0 takes on a value of 0.5 (as the graph shows to be perfectly possible), in order to make sharecropping the preferred option for the household, we would require a ratio for the wages to be

$$\left(\frac{w_0}{w_h}\right)^{\frac{-\lambda}{1-\lambda-\gamma}} > 2 \tag{4.25}$$

or the sharecropper's opportunity wage to be far below that of the hired worker plus supervision costs ($w_o < 1.74 w_h$).

Sharecropping would be preferred, for example, if the supervision costs are 60%, the hired wages are the same as the sharecropper's opportunity costs, and lambda exceeds 0.55.

High values of λ typically coincide with technologies that are largely based on labour. For in these cases, high shares of the revenues would accrue to the factor labour. If λ falls, due to other factors of production that demand a share of the revenues, such as land scarcity, other inputs or capital (such as motor pumps), the opportunities for sharecroppers fall. Only at very low relative wages would sharecropping still be the preferred option for landlords.

At large plots that would typically show a relatively ample availability of land compared to labour, we would expect relatively high values of λ, and more incidence of sharecropping than there would be at very small plots. Similarly, with other capital inputs, such as motor pumps, we should expect less use of sharecroppers.

Comparing to household labour, a sharecropping contract would be preferred if:

$$(1-\beta)\beta^{\frac{\lambda}{1-\lambda-\gamma}}(1-\lambda)^{\frac{\lambda-1}{1-\lambda-\gamma}}\left(\frac{w_0}{w_e}\right)^{\frac{-\lambda}{1-\lambda-\gamma}} > 1 \tag{4.26}$$

or

$$\begin{aligned}&\left(\frac{w_0}{w_e}\right)^{\frac{-\lambda}{1-\lambda-\gamma}} > (1-\beta)^{-1}\beta^{\frac{-\lambda}{1-\lambda-\gamma}}(1-\lambda)^{\frac{1-\lambda}{1-\lambda-\gamma}}\\ &\Leftrightarrow \frac{w_0}{w_e} \le (1-\beta)^{\frac{1-\lambda-\gamma}{\lambda}}\beta(1-\lambda)^{\frac{\lambda-1}{\lambda}}\end{aligned} \tag{4.27}$$

Comparing to household labour, a wage labour contract would be preferred if the hired wage paid to hired wage workers, supervision costs included, is lower than the household opportunity cost or wage:

$$w + \sigma w_e < w_e \tag{4.28}$$

The household's efficiency is reflected in its allocation of land to hired wage workers, sharecroppers or family workers. As the allocation is done plot by plot, rather than as a continuous function of the size of the farm, we can compare the plot regimes and simulate the profits that would arise if another regime would be applied. For each farm, we can simulate whether another regime than presently applied would yield higher profits to the household. If so, the household should be considered inefficient, as an option for higher profits is not used.

Another comparison of efficiency can be made at the level of the plots themselves. As the optimality conditions show, we should expect the marginal product of hired workers to equal their wages plus the costs of supervision, both measured per unit of labour (say an hour). The marginal product of the sharecropper's labour should equal his wage rate divided by the share accruing to him:

$$\left(\frac{w_o}{\beta}\right). \tag{4.29}$$

The input of fertilizer follows different laws for hired worker plots and sharecropped plots. On the latter plots, the input-output ratio of X in the above formula (equations 4.16 and 4.18) equals

$$\frac{X_s^*}{Y_s^*} = \frac{\gamma}{1-\lambda}\frac{p_y}{p_x} \tag{4.30}$$

whereas on hired-worker plots, it would be only

$$\frac{X_w^*}{Y_w^*} = \gamma\frac{p_y}{p_x}. \tag{4.31}$$

This, too, can be compared on a plot by plot basis, depending on the regime. We will do all these tests.

4.5. The empirical analysis

4.5.1. Functional forms and variables

The technology is assumed to be similar over labour contract. The production function is considered as translog instead of a pure Cobb-Douglas function, in order to capture the interaction between a number of variables. Preliminary, all the squared variables and interactions terms were used, but most of them were dropped because they were not statistically significant at the 10% level and did not improve the model. Finally, the log-linear functional form of the production function estimated was specified as follows:

$$\begin{aligned}&\log Y_{hic} = \alpha + \lambda_1 \log Lab_{hic} + \gamma \log Input_{hic} + \delta \log Plot_{hic} + \chi Mp\_01_{hic} + \\ &\lambda_2 \log LabMp_{hic} + \phi S\_01_{hic} + \eta Soil\_01_{hic} + \varepsilon_{hic}\end{aligned} \qquad (4.32)$$

where in household h, on plot i (i=1, 2, ..n) and for crop c $\in$ {all, onion, cabbage, tomato}, the dependent variable logarithm output in value per plot (log Y_{hic}) is a function of logarithm of:

- *Lab*, the aggregated working time of household labour or sharecropping labour or wage labour, depending on the labour contract, in hours per plot;
- *Plot*, plot area cultivated in square meters;
- *Input*, the aggregated costs in fcfa per plot of non-labour inputs used, such as mineral fertilizers (urea and NPK);
- *Mp_01*, dummy variable for a motor pump (1=motor pump used for plot irrigation, 0=otherwise),
- *LabMp*, the interaction labour and motor pump (logarithm (labour) *dummy motor pump);
- *S_01*, dummy variable for horticultural season (1= 1^{st} and 2^{nd} seasons, 0 = 3^{rd} season);
- *Soil_01*, dummy variable for soil suitability appreciation by the plot manager (1=good or medium, 0=bad);
- ε_{hic},, error term.

4.5.2. Endogeneity and the choice of estimator

In the production function, problems of endogeneity, related to a measurement error or simultaneity and reverse causality, may arise particularly with the explanatory variables input (fertilizers), labour (household labour, sharecropping labour, or wage labour) and the interaction labour-motor pump. This endogeneity may lead to a correlation between these explanatory variables with the error terms making the ordinary least squares (OLS) estimates biased and inconsistent (Verbeek, 2008).

To test the potential endogeneity of the variables input, labour, and interaction labour-motor pump, the Durbin-Wu-Hausman test was done. Each of these endogenous right-hand side variables was estimated as a function of all exogenous variables to obtain the reduced-form equations. The residuals predicted from each reduced-form equation were added to the structural form of the production function. The t-test done showed that the residuals were significantly different from zero (p=0.05), suggesting a non-zero covariance between the error term and the variables input, labour, and interaction labour-motor pump. Consequently, the test confirmed the endogeneity of these variables. In such a situation, instrumental variables should be used; the Generalized Instrumental Variable (GIVE) known as the Two-Stage Least Squares (2SLS) is one of the best alternative estimators.

Furthermore, the test of parameters done showed that the variables “use of garden hose for irrigation”, “use of sprinkler for irrigation”, “sharecropping dummy”, “share of women’s off-farm income”, “share of men’s off-farm income”, “log women’s total annual income”, “land owned”, “bovine cattle”, “log plot-household distance”, and the interaction terms “share of women’s off-farm income and motor pump” and “log women’s total annual income and motor pump”, may be considered as strong instruments, because they are significantly correlated with the endogenous variables (p=0.001 to p=0.07) in the reduced forms. With the F-statistic greater than 10, following the Stock-Watson rule-of-thumb (Verbeek, 2008), these variables can indeed be considered as strong instruments. We are careful about the problem of endogeneity and we did our best to identify these variables as valuables instruments. However, we are also cautious about the perfect exogeneity of some of these instrumental variables[16].

As the data used are cross-sectional, with household as the first sampling unit and plot the second one, for the estimation, the option standard errors “clustered robust” is used with household as cluster to allow for intra-household correlation, since the observations (plots) are independent across households (clusters) but not necessarily within households (repeated plot managers).

[16] Sprinklers, share of women’s off-farm income, share of men’s off-farm income, women’s total annual income may be not perfectly exogenous because of simultaneity or reverse causality with the output in value. We would prefer to have better instruments but we could not have them.

4.6. Empirical results and discussion

4.6.1. A comparison of plot size, inputs use intensity and output across labour contract

A cluster analysis based on plot area shows that most of the plots cropped by household labour are small-sized (46%) and medium-sized (40%). Few producers are cropping large plots (14%). Household labour is pre-dominantly used on small-sized plots, while sharecropping is mostly used on medium-sized plots, followed by large-sized plots (table 4.1). In fact, a certain plot size and level of irrigation equipment are required to hire labour based on a sharecropping contract. As the sharecroppers have limited access to off-farm work and as the off-farm wages are low, sharecroppers require a certain plot size, where they can maximize their labour.

Only households with a large plot size hire labour based on a wage contract. When households have large farm with relatively improved irrigation equipment (a motor pump, sprinklers, a drip system), they usually opt for hiring labour based on a wage contract rather than a sharecropping contract to complement the household labour. As can be read from table 4.1, on average, plots based on wage labour are much larger than plots based on sharecropping and household labour; the differences are significant at the 1% level.

Table 4.1: The distribution of labour across clusters, based on plot size cropped

Variables	Clusters		
	Small plot size	Medium plot size	Large plot size
Plot area (ha)	0.03	0.16	0.63
Plots under household labour (%)	0.86	0.45	0.30
Plots under sharecropping (%)	0.13	0.47	0.39
Plots under wage labour (%)	0.01	0.07	0.30
Observations (number of plots)	183	161	56

The intensity of the use of labour and other inputs, like mineral fertilizers, as well as the output in value per hectare are compared across labour contract. Table 4.2 shows the descriptive statistics of inputs and output on plots under household labour, sharecropping labour, and wage labour contracts. Horticultural production is highly labour-intensive, particularly when the irrigation is done manually, as is the case in most of the households. Plots based on household labour are much more labour-intensive than plots under a sharecropping or wage labour contract. These differences are significant at the 1% level. Even when labour is hired under sharecropping, household labour contributes to the time-consuming cropping operations such as transplanting, weeding and harvesting. Wage labour is usually hired to complement household labour; with wage labour, much more supervision is required compared to sharecropping. For these reasons, the time spent by household labour on plots under wage labour is greater than that on plots under sharecropping labour is. The difference is significant at the 10% level.

The time spent per hectare by sharecropping labour is much higher than that by wage labour. Hired wage workers work less than sharecroppers. This may be explained by their difference regarding involvement and risk, but also by the difference in the level of irrigation equipment of the plots. Sharecroppers have more incentives and commitment to work well, and share the risk because they earn half the profit. Hired wage workers, on the other hand, have a fixed wage, whatever the results of the production may be, and this may dampen their incentives to work harder. As underlined by Ahmed *et al.* (2002), hired wage labour should have weaker work incentives compared to tenants under sharecropping. Wage labourers do not share any risk, even if their working performance may somewhat determine the chances of their working contract being renewed. In most of the contracts, the working time is predefined. The enforcement mechanism used by the landlord consists of being present on the field, in order to be able to observe and supervise the wage labour work. The fact that the payment is usually made only after the harvest is also a contributing factor.

Plots based on wage labour are significantly better equipped than those based on household labour and sharecropping labour. Motor pumps are most often used for irrigation on plots under a wage labour contract. Plots based on household labour or a sharecropping contract are more intensive in inputs, such as mineral fertilizers, compared to plots under a wage contract. The crossed differences are significant at the 10% level. The output in value per hectare is lower on plots under a wage labour contract, compared to plots under household labour or a sharecropping contract; the difference is significant at the 10% level. However, there is no significant difference of output in value per hectare between plots under household labour or sharecropping labour.

Table 4.2: A comparison of input use intensity and output across labour.

Variables	Labour type					
	Household labour		Sharecropping labour		Wage labour	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Plot area (ha)	0.10	0.17	0.22	0.20	0.47	0.30
Household labour (hr/ha)	22,273	27,683	1,369	1,653	2,061	2,227
Sharecropping labour (hr/ha)	0	0	6,986	6,477	0	0
Wage labour (hr/ha)	0	0	0	0	1,547	1,669
Input cost (fcfa/ha)	222,385	223,539	194,301	157,492	151,807	103,508
Motor pump_01 (1=pump)	0.13	0.33	0.17	0.38	0.34	0.48
Output (fcfa/ha)	4,272,630	2,922,235	4,135,407	3,012,896	3,297,387	1,841,990
Observations (plots)	249		124		29	

4.6.2. An estimation of the production functions

Table 4.3 presents the descriptive statistics of the variables used in the production functions estimation.

Table 4.3: Descriptive statistics of variables used in the plot level, crop-specific production functions estimation.

Variables	Overall crops		Onion		Cabbage		Tomato	
	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.
Output value (fcfa)	601,693	93,318	772,039	1,112,354	432,843	717,881	288,213	345,348
Labour (hour)	955	1,456	1,480	2,119	619	533	518	283
Input (fcfa)	27,290	43,055	32,247	51,018	21,141	31,396	71,345	14,834
Plot area (m^2)	1,720	2,204	1,696	1,960	1,404	2,008	1,081	1,264
Motor pump_01	0.15	0.36	0.01	0.13	0.22	0.41	0.21	0.41
Season_01	0.94	0.23	1	0	0.88	0.31	0.90	0.29
Soil suitability_01	0.98	0.10	0.98	0.11	1.00	0.00	0.96	0.17
Garden hose_01	0.18	0.38	0.01	0.11	0.16	0.37	0.24	0.43
Sprinkler_01	0.08	0.27	0.006	0.07	0.04	0.21	0	0
Sharecropping_01	0.29	0.45	0.43	0.49	0.23	0.42	0.27	0.45
Share of women's off-farm income (%)	32.78	38.18	21.33	30.84	34.41	38.26	39.61	40.00
Share of men's off-farm income (%)	20.77	23.74	23.66	21.65	19.44	24.85	18.52	23.51
Women's annual income (fcfa)	342,803	493,124	290,446	315,905	415,695	579,432	330,759	646,992
Land owned (ha)	4.03	3.78	3.69	3.88	4.18	3.46	4.09	3.01
Bovine cattle	4.60	8.76	5.88	10.32	3.65	7.48	4.56	8.99
Distance house-plot (km)	1.37	1.19	1.16	0.96	1.57	1.32	1.46	1.37

Table 4.4 presents the results of the 2SLS and OLS estimations of the production functions for overall horticultural crops and for the dominant specific crops, such as onion, cabbage and tomato, using data at the plot level. For other horticultural crops, such as potato and green bean, the limited number of observations (respectively 9 and 11) did not allow the estimation of their crop-specific production functions, particularly when 2SLS is used. The results of the estimation differ from those of the previous chapter, because of the difference of the variables controlled in the production function and the estimation procedure. In the previous chapter, the stochastic frontier production functions were estimated with a maximum likelihood for cross-sectional data, in order to derive the efficiency scores. Here, mean production functions are estimated rather than frontier production functions.

The estimates of the 2SLS differ from those of the OLS. Since OLS is supposed to be biased and inconsistent because of the endogenous variables input, labour, and labour*pump, the analysis focuses on the 2SLS estimates. As the production functions estimated are log-linear models, the coefficients of the different inputs used can be interpreted as elasticities. Thus, the coefficients are also equivalent to the percentage change in the output in value, resulting from a one percent change in the explanatory variables. Regarding overall crops, except the variable motor pump and its interaction with labour and variable soil suitability, all other variables are significant at least at the 5% level. In terms of elasticity, the coefficients show that a one percent (1%) increase in labour time, whether household labour or sharecropping or wage labour, leads to an increase by 0.39% of the output in value per plot if there is no motor pump, and only by 0.09% if there is a motor pump. The output in value is significantly responsive to input (mineral fertilizers), with an elasticity of 0.53%. A one percent increase in plot area cropped also results in an increase of 0.36% of the output in value per plot. The seasonal effect is significant and negative, which means that it is increasing from the first and second seasons (November-February and March-June, respectively) to the third season (July-October). This seasonal effect reflects the higher output prices observed in the third season.

Table 4.4: The Two-Stage Least-Squares (2SLS) and Ordinary Least-Squares (OLS) estimation for plot level crop-specific production functions (robust clusters in households).

Dependent variable: Log output in value (fcfa)	Overall crops		Onion		Cabbage		Tomato	
	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS
Log Labour (hr)	0.39**	0.28***	0.56	0.36***	0.43	0.20*	0.61*	0.33*
	(0.19)	(0.05)	(0.40)	(.07)	0.35	(0.11)	0.35	(0.17)
Log Input (fcfa)	0.53**	0.14*	0.38*	0.05	0.52**	0.11*	0.36***	0.48**
	(0.23)	(0.08)	(0.23)	(0.08)	0.24	(0.06)	0.12	(0.20)
Log Plot area (m2)	0.36**	0.69***	0.33	0.71***	0.34*	0.70***	0.54***	0.46***
	(0.17)	(0.07)	(0.30)	(0.08)	0.19	(0.06)	0.09	(0.16)
Motor pump_01	1.51	0.82		14.11***	2.08	0.93	2.73	0.64
	(2.33)	(0.85)		(5.14)	2.78	(1.05)	3.87	(3.29)
Log labour*	-0.30	-0.17	-0.23	-2.09***	-0.34	-0.13	-0.54	-0.25
Pump_01	(0.36)	(0.12)	(0.29)	(0.81)	0.43	(0.16)	0.62	(0.51)
Season_01	-.65***	-0.47			-0.42***	-0.40***	-0.94***	-1.02***
	(0.20)	(0.14)			0.18	(0.16)	0.35	(0.42)
Soil suitability_01	-0.08	-0.08***	0.59**	0.25			-0.46	-0.31
	(0.28)	(0.19)	(0.26)	(0.18)			0.33	(0.37)
Constant	3.19***	5.25***	2.33	4.66***	2.88	5.73***	3.05*	4.04
	(1.06)	(0.37)	(1.87)	0.33	2.40	(0.65)	1.63	(1.07)
N (plots)	336	382	141	156	134	138	53	63
Cluster (household)	140	169	72	81	94	98	46	56
R2	0.72	0.77	0.74	0.86	0.72	0.79	0.71	0.59
Wald Chi2 or F	1302***	317***	3937***	390***	632***	138***	179***	22***
Instrumented	Log Input (fcfa), Log labour, Log labour*pump_01							
Additional instruments	Garden hose_01, sprinkler_01, sharecropping_01, land, bovine cattle, share of women's off-farm income, share men's off-farm income, log plot-household distance, log women's annual income, share of women's off-farm work*motor pump, log women's annual income*motor pump							
Test of endogeneity: Robust F	2.40*		5.23***		1.52		0.63	
Test of overidentifying restrictions: Chi2	2.03 (p=0.84)		1.71 (p=0.42)		1.89 (p=0.86)		2.81 (p=0.72)	

***, **, * significant respectively at the 1%, 5%, and 10% level; robust standard errors in parentheses.

The effect of the use of a motor pump is positive (as long as log labour is lower than 5), while the interaction labour-motor pump is negative, showing a decrease of labour working time when a motor pump is used. As shown previously in the descriptive chapter, irrigation is the most time-costly cropping operation, particularly when it is done manually, with 75% and 85% of the total time, respectively, on men's and women's plots. Thus, it is important to understand the effect of a motor pump on the reduction of the working time, even if it is statistically not significant at the 10% level. Soil suitability appreciation is negatively related to the output in value, but not significant at the 10% level as well. With an R-squared of 0.72, the model shows a high goodness of fit for such cross-sectional data. The robust test of endogeneity is significant at the 10% level, confirming that the variables input, labour, and interaction labour-motor pump are indeed endogenous. The test of overidentifying restrictions is not significant (p=0.84), suggesting the validity of all the instruments used and the well-correct specification of the model. However, we are suspicious about the high coefficients of the variable input (fertilizer). This may be due to the instruments used or the variable input may capture other effects, such as the managerial capacity of the producers.

As can be read from table 4.4, crop-specific production functions present a great difference. The responsiveness of the variables differs from one crop to the other, as shown by the difference in terms of magnitude and significance of the coefficients. While the onion output is significantly responsive (at the 10% level) to inputs and soil suitability, the cabbage output is responsive to input and plot area, and tomato to input, plot area, and labour. As for overall crops, the seasonal effect is significant for cabbage and tomato. One percent increase in mineral fertilizers input leads to an increase of 0.36%, 0.38% and 0.52% of output in value respectively for tomato, onion and cabbage. So, cabbage is more responsive to fertilizers than the other crops. The high values of the R-squared (0.71 - 0.74) signal a goodness of fit of the crop-specific production functions. Variables such as a motor pump, the season, and soil suitability are dropped on the onion production function because they are quite invariant. The same goes for the variable soil suitability in the cabbage production function.

The technology shows an increasing return to scale, with a total elasticity of land, labour and input greater than one on plots without a motor pump. This means that scaling up all inputs by one unit may lead to an increase of the output in value by more than one unit for all crops as well as for each crop. Thus, plots without a motor pump are smaller than the optimal size. Contrary, on plots irrigated with a motor pump, the technology displays a constant return to scale, with a total elasticity close to one (table 4.5).

Table 4.5: The return to scale, controlling for crop and irrigation equipment

Plots	All crops	Onion	Cabbage	Tomato
Without a motor pump	1.28	1.27	1.29	1.51
With a motor pump	0.98	1.04	0.95	0.97

4.6.3. Household profit optimization across plots under a sharecropping labour contract and a wage labour contract

For each plot under a wage labour contract, we collected the time spent by household labour and wage workers. For each plot, the ratio time spent by household labour and time spent by hired wage workers was computed. The result shows that, for all crops, for each unit of wage labour working time, a household spent on average 0.96 units of time supervising hired workers and working, since wage labour is generally hired in order to complement household labour. According to households hiring wage labour and the agricultural technicians working on the extension services, the supervision itself represents on average a quarter of the time spent by household members. For each unit of wage labour working time, a household spent on average 0.96 units of time, of which 0.24 was for supervision and 0.72 for a contribution to cropping operations. The supervision rate varies greatly from one household to another and from one crop to another. As can also be seen from the kernel density (figure 4.3), most of the household members spent about 0.20 of their time supervising the wage labour, while very few spent more than 0.30 for each unit of wage labour working time.

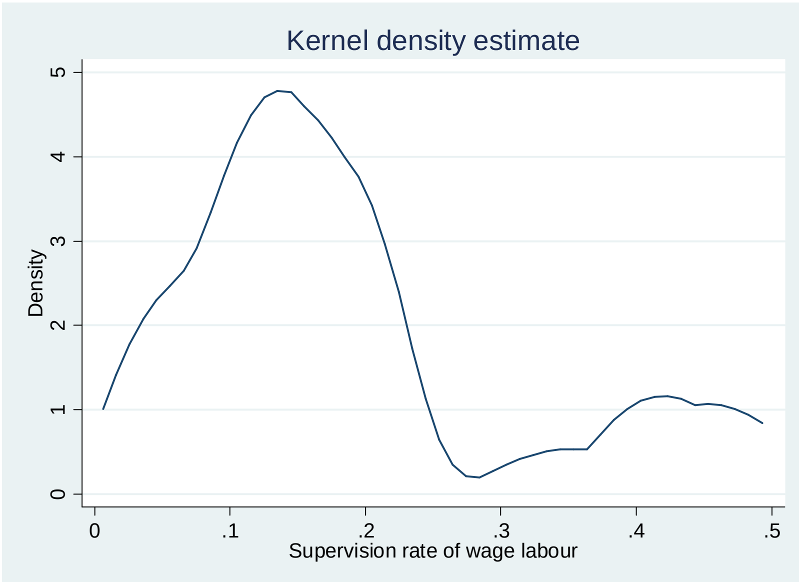


Figure 4.3: Distribution of the supervision rate of wage labour.

As defined in the household model (equation 4.23), the profit derived by the household from a plot under a sharecropping contract is higher than that from a plot under a wage contract if the profit ratio

$$\frac{\pi_s^*}{\pi_w^*} > 1 \Leftrightarrow \frac{(1-\beta)}{(1-\lambda)}\left(\frac{\beta^{\lambda}}{(1-\lambda)^{\gamma}}\right)^{\frac{1}{1-\lambda-\gamma}}\left(\frac{w_0}{w_h}\right)^{\frac{-\lambda}{1-\lambda-\gamma}} > 1 \qquad (4.23)$$

with $w_h = w + \sigma\, w_e$

where :

- β is the share of profit paid to sharecroppers, equal to 0.5;
- λ is the production elasticity of labour: $\lambda = \lambda_1 + \lambda_2$ *motor pump_01. For each plot, λ was calculated.
- γ is the production elasticity of other inputs (mineral fertilizers);
- σ is the supervision rate of wage labour;
- w_o is the sharecropper's opportunity cost or wage for farm or off-farm work;
- w_e is the household opportunity cost or off-farm wage;
- w is the wage paid to hired wage labour by the household;

- w_h is the wage paid by the household to wage labour, including the supervision cost σ w_e.

As expected, it can be deduced from the production function estimated (table 4.4) that higher values of λ are obtained without a motor pump (λ=0.39 for overall crops, 0.56 for onion, 0.43 for cabbage, and 0.61 for tomato). When a motor pump is used, the production elasticity of labour falls (λ=0.09 for overall crops, 0.33 for onion, 0.09 for cabbage, and 0.07 for tomato) because the irrigation equipment takes a share of the revenue or output in value. Consequently, it is hypothesized that when a motor pump is used, producers would not prefer to hire labour based on sharecropping so much because it is less profitable.

Given β and the estimates λ and γ of the production function (table 4.4), simulations were made at plot level to calculate the optimum profit ratio π_s^*/π_w^* above (equation 4.23):

- first, by setting the opportunity cost of sharecropping equal to the wage paid to wage workers by the household, including supervision costs: $w_o=w_h$ or $w_o/w_h=1$;
- second, by setting the opportunity cost of sharecropping lower than the wage paid to wage workers by the household, including supervision costs ($w_o< w_h$), but equalizing hired wages for household plot managers, sharecroppers, and wage labourers ($w_e=w_o=w$) and varying the supervision costs of wage labour (σ). This means varying w_o/w_h (figure 4.4).

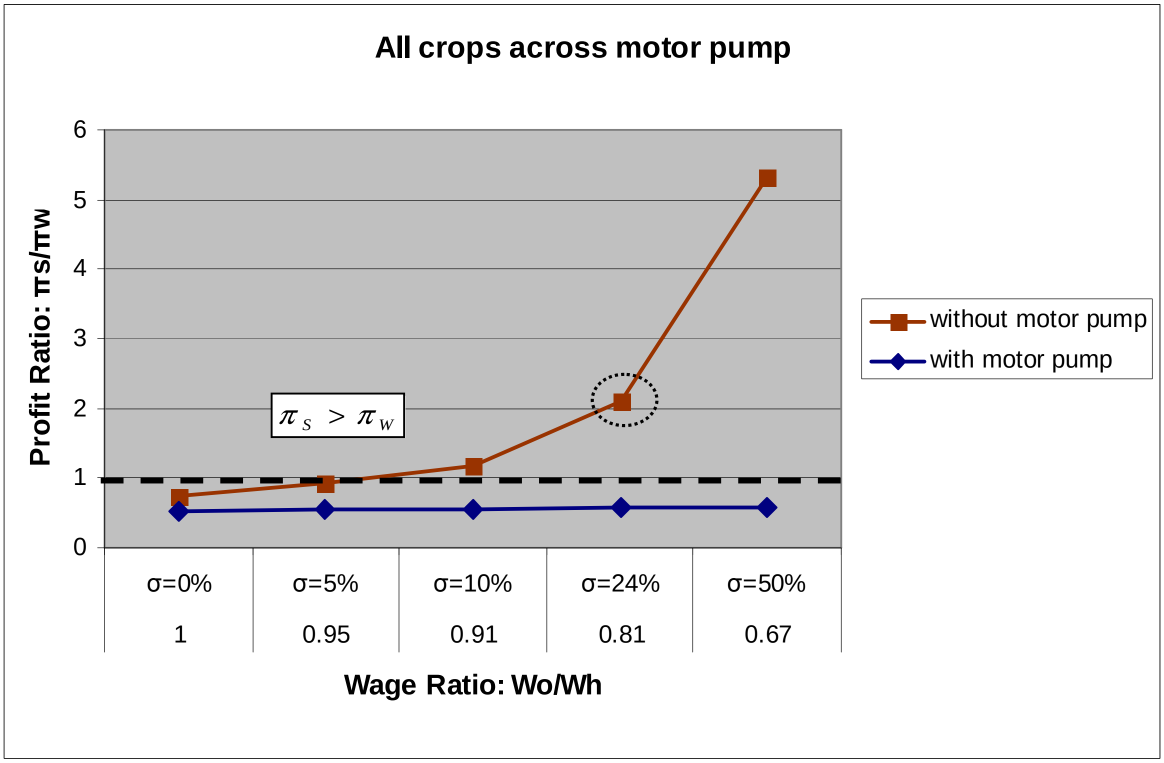


Figure 4.4: A comparison of the average optimum profit derived by the household from plots under a sharecropping contract and a wage labour contract and controlling for a motor pump.

Figure 4.4 is based on the estimates of the production function and shows the variation of the average profit ratio π_s^*/π_w^* (equation 4.23), varying the wage ratio w_o/w_h and the supervision rate σ. As can be read from figure 4.4, the results of the simulations of the profit ratio π_s^*/π_w^* show that if the opportunity cost or wage of sharecroppers equals the wage paid by the household to hired wage labour plus their supervision cost (w_o=w_h or w_o/w_h =1), for overall crops, the optimum profit derived by the household from a sharecropping contract is lower than that from a wage labour contract (profit ratio π_s^*/π_w^*<1). This is the case whether a motor pump is used for irrigation on the plot or not. Consequently, at equal wages, for overall horticultural crops, the household would prefer to hire labour based on a wage contract rather than a sharecropping contract to maximize profit. This conclusion also holds for onion, cabbage and tomato.

The production elasticity of labour (λ) falls when a motor pump is used for irrigation, and as can be observed from graph 4.4, the profit ratio π_s^*/π_w^* (equation 4.23) is much lower, making sharecropping less profitable compared to the same case without a motor pump. When the ratio opportunity cost or the wage of the sharecroppers and the wage paid by the household to hired wage labour, supervisions cost (w_o/w_h) included, decreases, or the other way round, when the wage paid by the household to hired wage labour becomes much higher (due to a higher supervision rate) than the opportunity cost of the sharecroppers ($w_h>w_o$), the profit ratio π_s^*/π_w^* increases. When w_o/w_h is equal to 0.9, corresponding to a supervision rate (σ) of about 10%, the profit ratio π_s^*/π_w^* becomes greater than one and, consequently, the profit derived by the household from plots under a sharecropping contract is higher than that from a wage labour contract ($\pi_s^*>\pi_w^*$). This applies to plots without a motor pump, whereas for plots irrigated with a motor pump, a wage labour contract would be more profitable.

Considering the average rate of the supervision of wage labour applied by a household, which is 24%, the ratio opportunity cost or the wage of sharecroppers and the wage paid by the household to hired wage labour (w_o/w_h) is equal to 0.81, while the profit ratio π_s^*/π_w^* is equal to 2.10 for plots without a motor pump and 0.56 for plots irrigated with a motor pump. Consequently, on average, the profit ratio π_s^*/π_w^* is greater than one on plots without a motor pump, contrary to plots with a motor pump. This result suggests that, on average, on plots without motor pumps, a sharecropping contract provides to the household a higher optimum profit than a wage contract does. However, on average, on plots irrigated with a motor pump, a wage labour contract leads to more optimum profit than a sharecropping contract does. On these plots with a motor pump, the simulations show that even when the wage paid by the household is two times greater than the wage of a sharecropper ($w_o/w_h=1/2$), corresponding to a supervision rate of 100%, the household would still prefer to hire labour based on a wage labour contract rather than on sharecropping. Definitively, on plots equipped with a motor pump, hiring labour based on a wage contract is always more profitable for the household than that based on a sharecropping contract.

For crops like onion, cabbage and tomato, and without a motor pump, a sharecropping contract leads to a higher optimum profit for the household (profit ratio $\pi_s^*/\pi_w^*>1$) compared to wage contract, at the average rate of supervision applied by the household *(*σ=24%), corresponding to a wage ratio of w_o/w_h, equal to 0.81. When plots are irrigated with a motor pump, at this average rate of supervision, hiring labour based on a wage contract is more profitable for the household (profit ratio $\pi_s^*/\pi_w^* <1$).

Graph 4.5 provides a better illustration of the optimization of the household's profit under a labour contract, controlling for crop and motor pump. As can be seen from the graph, the profit optimization from plots equipped with a motor pump differs from that without a motor pump. While cabbage and onion present the same profit optimization, there is a great difference regarding tomato. To sum up, without a motor pump, for all crops together as well as for each crop, sharecropping becomes the most profitable labour choice when the wage ratio w_o/w_h decreases corresponding to an increase of the supervision costs of wage labour. However, when plots are equipped with a motor pump, sharecropping is not the optimum choice, either at 0% or at 100% of the supervision cost for overall crops and for most of the crops.

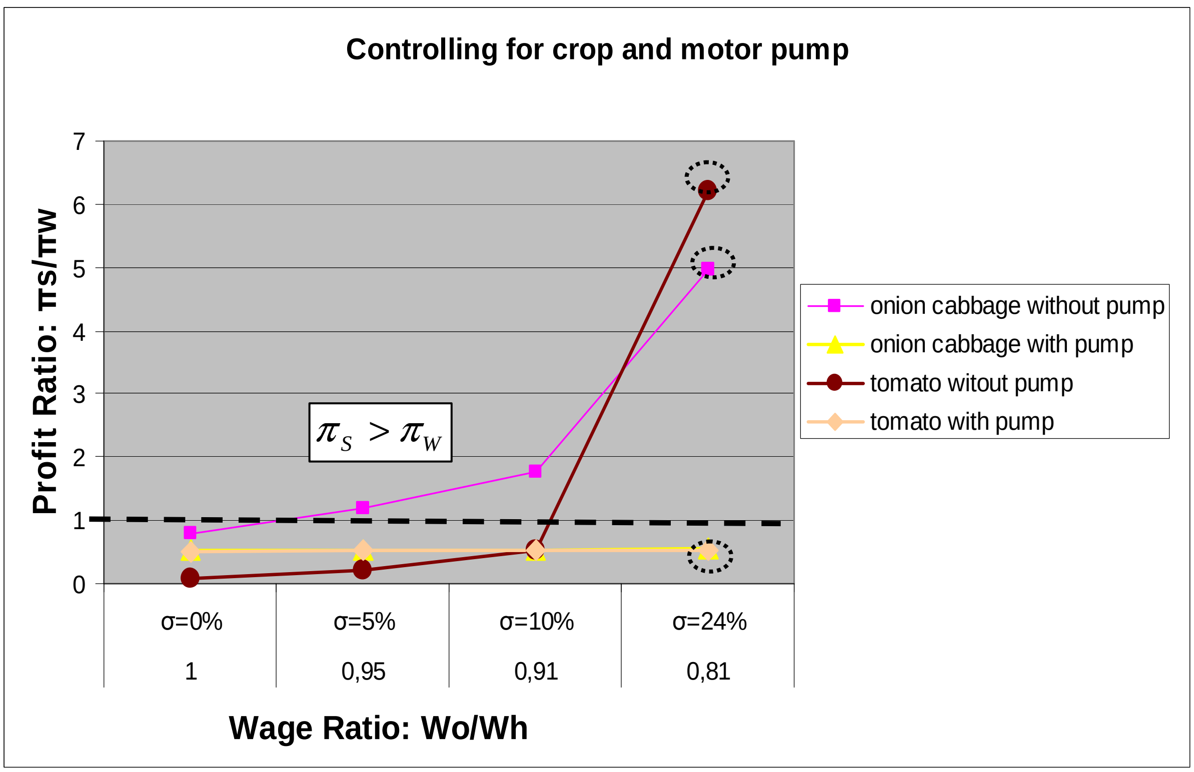


Figure 4.5: A comparison of the average optimum profit derived by the household from plots under a sharecropping contract and a wage labour contract, and controlling for crop and motor pump.

4.6.4. An efficiency test of the labour contract choice based on optimum profit: the sharecropping labour contract versus the wage labour contract

The test was done for overall crops as well as for cabbage and tomato. Due to limited observations under a wage labour contract, the test was not done for onion. Figure 4.6 presents the results of the simulations of the ratios by labour contract.

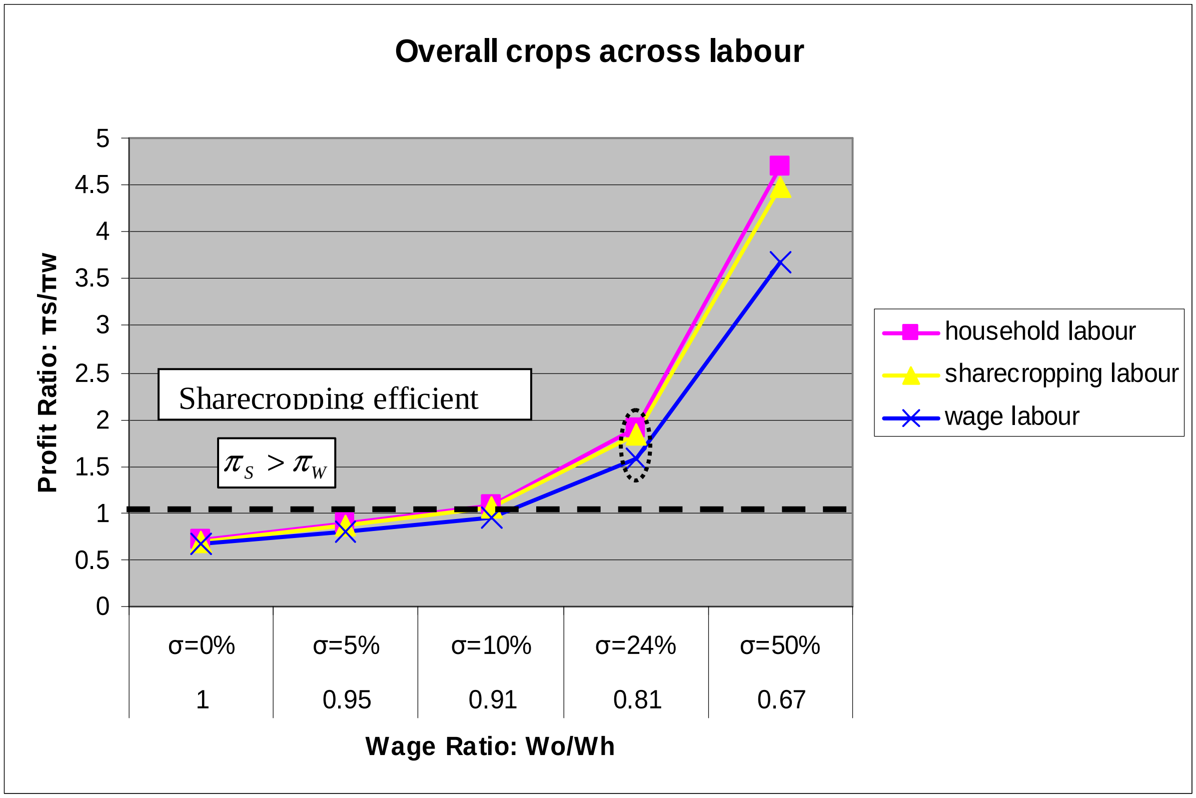


Figure 4.6: An efficiency test of labour contract choice based on optimum profit and varying supervision rate or wage ratio: sharecropping labour contract versus wage labour contract.

For overall crops, on plots based on household labour, sharecropping labour and wage labour, when w_o/w_h is equal to 0.9, corresponding to a supervision rate (σ) of about 10%, the profit ratio π_s^*/π_w^* becomes greater than one, implying that the optimum profit derived from a sharecropping contract is higher than that derived from wage contract. Consequently, from 10% of the supervision rate, the labour choice is efficient on plots based on sharecropping labour and is not efficient on plots based on a wage contract.

Considering the average rate of supervision of wage labour (σ=24%) applied by the household and corresponding to a wage ratio w_o/w_h equal to 0.81, the profit ratio π_s^*/π_w^* is greater than one on plots without a motor pump, whether under sharecropping, a wage contract or household labour, and for overall crops as well as for each crop. These findings mean that, on average, the labour choice is efficient on plots without a motor pump and under sharecropping labour, because this choice provides the highest optimum profit to the household. Contrary, on average, the labour choice is not efficient on plots without a motor pump and under wage labour. Inversely, when a motor pump is used for irrigation, the profit ratio π_s^*/π_w^* is always lower than one suggesting that a higher optimum profit would be derived from a wage labour contract. Accordingly, wage labour would be the efficient labour choice for plots equipped with a motor pump.

The analysis of the data shows that the labour choice is efficient on 82% of the plots under sharecropping labour and on 34% of the plots under a wage labour contract. Many plots without a motor pump under a wage labour contract would be under a sharecropping contract for household profit optimization. Altogether, plot managers made the right labour choice on 73% of the plots under a sharecropping or a wage labour contract (table 4.6).

Table 4.6: Plots with an efficient labour contract choice

Labour	Plots			Plots with an efficient labour contract choice	
	Total	Without a motor pump	With a motor pump	Frequency (plots)	Percent
Sharecropping labour contract	124	102	22	102	82
Wage labour contract	29	19	10	10	34
Total	153	121	32	112	73

On plots without a motor pump and based on household labour, simulations of the profit ratio π_s^*/π_w^*, considering the average supervision rate, indicate that a sharecropping contract would provide more optimum profit than a wage contract would, for overall crops and for each crop. Nevertheless, a further comparison is required to conclude about the efficiency of choosing household labour rather than hired labour, as is done in the following section.

4.6.5. An efficiency test of the labour contract choice based on optimum profit: household labour versus the sharecropping labour contract

Compared to household labour, a sharecropping contract is the efficient labour choice that maximizes the household's optimum profit for a given plot if, as shown in the model (equation 4.27):

$$\pi_s^* > \pi_h^* \Leftrightarrow \frac{w_0}{w_e} < (1-\beta)^{\frac{1-\lambda-\gamma}{\lambda}} \beta(1-\lambda)^{\frac{\lambda-1}{\lambda}} \qquad (4.27)$$

where w_o and w_e respectively stand for the opportunity cost or the wage of the sharecropper and the household.

The ratio of the right-hand side of the equation 4.27 was calculated for each plot, controlling for crop, motor pump and labour. Table 4.7 presents the results of the estimation.

Table 4.7: Comparison of the optimum profit derived from a sharecropping labour contract (π_s) and household labour (π_h) for a given plot and controlling for crop, irrigation equipment, and labour.

Plots		Observations (plots)	$\pi_s > \pi_h$ if $w_o/w_e <$			
			Overall crops	Onion	Cabbage	Tomato
Motor pump	Without a motor pump	356	0.93	0.88	0.97	0.88
	With a motor pump	66	0.07		0.06	0.004
Labour	Household labour	249	0.82	0.88	0.81	0.76
	Sharecropping contract	124	0.78	0.88	0.69	0.54
	Wage labour contract	29	0.64		0.64	0.70

As can be read from table 4.7, the wage ratio presents a great difference, whether the plots are equipped with a motor pump or not. When plots are not equipped with a motor pump, sharecropping leads to a higher profit than household labour does, if the sharecropper's wage is nearly equal to the household wage ($w_o/w_e = 0.9$). However, when plots are irrigated with a motor pump, the wage ratios w_o/w_e should be lower for overall crops and for each crop to justify sharecropping. Accordingly, on plots irrigated with a motor pump, sharecropping can provide a higher profit than household labour could, if the household wage is several times (14 times) higher than the sharecropper's wage.

Moreover, controlling for labour and crop, as can be read from table 4.7, the results show that the wage ratio w_o / w_e should on average be lower than one for all crops and for each crop, to make sharecropping more profitable than household labour would be. In other words, on average, the household would prefer to hire labour based on a sharecropping contract rather than using household labour if the household's wage is higher than the sharecropper's wage.

In terms of efficiency implications, the labour choice will be efficient on plots based on household labour if the profit derived from plots based on household labour is higher than that from sharecropping ($\pi_h > \pi_s$). This is equivalent to the wage ratio w_o/w_e, higher than the values indicated on table 4.7. Inversely, the labour choice will be efficient on plots based on sharecropping ($\pi_s > \pi_h$) if the wage ratio w_o / w_e is lower than the values indicated on table 4.8. At equal wages ($w_o = w_e$), the labour choice would be efficient on plots based on household labour, whereas it would be inefficient on plots based on sharecropping labour for overall crops and for each crop.

4.6.6. An efficiency test of the labour contract choice based on optimum profit: household labour versus the wage labour contract

The wage rate (w) paid by the household to hired wage labour varies from fcfa 68 to fcfa 833, with an average of fcfa 310 per hour for overall crops and plots. The hourly wage varies greatly from one household to another, from one crop to another, and whether the plot is equipped with a motor pump or not. It is lower on plots with a motor pump than on plots without a motor pump, where the irrigation is more demanding. The explanation may be that with a motor pump the irrigation work becomes easier. Table 4.8 presents the wage paid across plots, crops, and motor pump.

Table 4.8 Descriptive statistics of the wage paid by the household to hired wage labour across plots, crops, and motor pump (fcfa/hr).

Plots	Wage w paid by the household to hired wage labour (fcfa/hr)				
	Overall crops			Cabbage	Tomato
	Mean	Min	Max	Mean	Mean
Overall plots	310	68	833	272	331
Plots without a motor pump	323	68	833	276	380
Plots a with motor pump	266	183	397	247	183

As shown in the household model, compared to household labour, a wage labour contract would provide a higher profit to the household if: $w + \sigma w_e < w_e$.

Knowing w, the wage paid per hour by the household to hired wage labour, and σ, the supervision rate, it is possible to estimate the household wage w_e, at which a wage labour contract is more profitable than household labour. If household members spend more time on the plot than wage labourers, supervising the hired labour ($\sigma>1$), the ratio will be negative, so this case has not to be considered and is even unrealistic. Only the other case is considered ($\sigma<1$). Table 4.9 presents the results of the estimation.

Table 4.9: A comparison of the optimum profit derived from a wage labour contract (π_w) and household labour (π_h) for a given plot and controlling for crop and irrigation equipment.

Plots	w/(1- σ) in FCFA/hr ($\pi_w > \pi_h$ if $w_e > w/(1-\sigma)$)		
	Overall crops	Cabbage	Tomato
Overall plots	378	349	435
Plots without a motor pump	393	332	507
Plots with a motor pump	318	451	219

As can be read from table 4.10, the optimum profit derived from plots based on a wage labour contract (π_w) would be higher than that from plots based on household labour (π_h) if the household wage (w_e) is greater than fcfa 378 per hour for overall crops and plots. When the plot is equipped with a motor pump, the household wage above which hiring wage labour is more profitable than using only household labour is lower. This is also the case for tomato, while it is the opposite for cabbage. Thus, controlling for crop and motor pump, some difference appears with regard to the wage above which hiring labour is more profitable than using household labour.

In general, on the labour market, household members and sharecroppers may find a wage varying from fcfa 1,000 to 2,000 per working day of 7 hours (9h-16h). This is an hourly wage varying from fcfa 142 to 285. At these wage rates, on average, the optimum profit derived from plots under a wage labour contract is lower than that from plots based on household labour. This may explain the reason why so very few households (7%) are hiring labour based on a wage contract. Accordingly, horticultural households would have incentives to hire wage labour if they could find a better wage rate on the labour market (about fcfa 2500-3000 per day).

4.6.7. An efficiency test of inputs use based on household profit optimization across labour contracts

The ratios cost of the non-labour input (mineral fertilizers) and the output value were computed and compared with the efficient ratios on plots under different labour contracts and irrigation equipments (table 4.10). As shown in the household model, the efficient input/output ratios were derived from the optimum conditions and differ from plots under a sharecropping contract to plots under a wage labour contract (equations 4.30 and 4.31). The estimates corresponding to the efficient input/output ratios are apparently very high. This may be due to the 2SLS estimator used (instrumental variables), or the variable “input fertilizers” may also capture some other effects, such as the managerial capacity of the producers.

Table 4.10: The efficiency of the use of inputs based on household profit optimization across labour contract and crops.

Crops	Labour	Ratio Input/Output (R)	Efficient Ratio Input/Output (ER)	Efficiency score (R/ER)
Overall crops	Household labour	0.08 (0.14)	0.53	0.15
	Sharecropping labour	0.06 (0.06)	0.81	0.07
	Wage labour	0.07 (0.09)	0.53	0.13
Onion	Household labour	0.06 (0.06)	0.38	0.16
	Sharecropping labour	0.05 (0.04)	0.86	0.06
Cabbage	Household labour	0.07 (0.09)	0.52	0.13
	Sharecropping labour	0.07 (0.09)	0.80	0.09
	Wage labour	0.12 (0.13)	0.50	0.24
Tomato	Household labour	0.12 (0.28)	0.36	0.33
	Sharecropping labour	0.08 (0.07)	0.71	0.11
	Wage labour	0.03 (0.03)	0.36	0.08

Note: standard deviation in parentheses.

As can be read from table 4.10, controlling for crop and labour, the ratios input/output are much lower than the efficient ratios, indicating that the input fertilizer is not used efficiently. The efficient ratio over the input/output ratio gives the efficiency scores, which are rather far below one controlling for crop and labour contract, thus showing the low efficiency. In fact, for overall crops, it requires an increase by one percent of the input cost to efficiently increase the output value by 0.53% on plots under household labour or a wage labour contract, and by 0.81% on plots under a sharecropping contract. Evidently, the efficient ratios look very high and need to be taken “cautiously”. However, even with the OLS estimates, the efficient input/output ratios (0.18 on sharecropped plots and 0.14 on others) are lower than the efficient ratios. The expenditure in fertilizer input is on average less than 10% of the output in value for overall crops and for each crop, except for cabbage, on plots under a wage labour contract, and for tomato on plots based on household labour. The ratio input/output does not significantly differ (at the 10% level) across labour contract for overall crops and for each crop. Controlling for irrigation equipment and particularly for a motor pump, the same conclusion on low efficiency holds on plots without a motor pump as well as on plots with a motor pump for overall crops. However, although the ratios input/output are always lower than the efficient ratios, they are significantly higher (at the 1% level) on plots irrigated with a motor pump than they are on plots without a motor pump, and particularly on plots under household labour or a sharecropping contract.

4.7. Conclusion and policy implications

In Senegal, labour contracts are used by horticultural households' landowners as suitable strategies to overcome their labour deficit. They are also convenient arrangements for the tenants, who are landless because they come from areas that are inappropriate for horticulture. This chapter provides theoretical and empirical evidence by designing and testing a model based on household profit optimization, to compare the optimum profit derived from plots based on household labour, a sharecropping labour contract and a wage labour contract, while controlling for irrigation equipment. In doing so, this research makes a scientific contribution to the theory of land tenancy, using data from Senegal's Niayes Zone.

As expected, the estimation of the production function shows that the production elasticity of labour falls when improved irrigation equipment like a motor pump is used. The technology displays an increasing return to scale on plots without a motor pump and a constant return to scale on plots irrigated with a motor pump. This means that average plots without a motor pump are smaller than the optimal size. The findings suggest that when a motor pump is used, producers would prefer much less to hire labour based on a sharecropping contract instead of labour based on a wage contract.

The results of the simulations show that if the opportunity cost or wage of sharecroppers (w_o) equals the wage paid by the household to hired wage labour plus their supervision cost (w_h), controlling for crop (all crops, onion, cabbage and tomato) and for plot irrigation equipment, the optimum profit derived by the household on plots under a sharecropping contract is lower than that under a wage labour contract. Consequently, at equal wages, the household would prefer to hire labour based on a wage contract rather than a sharecropping contract to maximize profit. However, when the wage ratio w_o/w_h decreases, corresponding to an increase of the supervision costs of wage labour, sharecropping becomes the most profitable labour choice, but only without a motor pump. Considering the average rate of supervision of wage labour applied by the household which is estimated at 24%, the results suggest that, on average, on plots without motor pumps, a sharecropping contract provides to the household a higher optimum profit than a wage contract does. However, on plots irrigated with a motor pump, even if the wage paid by the household is two times higher than the wage of a sharecropper (w_o/w_h =1/2), corresponding to a supervision rate of 100%, the household would still prefer to hire labour based on a wage labour contract rather than on sharecropping. Consequently, we can conclude from this finding that the use of a motor pump drives out the sharecropping contract in favour of the wage labour contract.

In terms of the efficiency implication, the test of the labour contract choice based on optimum profit suggests that, at the average rate of the supervision of wage labour applied by the household (24%), without a motor pump, the labour choice is efficient on plots under sharecropping labour, because this choice provides the highest optimum profit to the household. However, on plots equipped with a motor pump, wage labour would be the efficient labour choice. Altogether, plot managers made the efficient labour choice on 73% of the plots under a sharecropping or a wage labour contract. Most of the households would like to have a motor pump but some of them cannot afford it because of lack of capital and limited access to credit. In that sense, in the short term the use of the motor pump may be considered as exogenous, but it may be endogenous in the long term. Actually, the households who have already a motor pump may choose to buy an additional one based on the expected returns.

A comparison of the sharecropping contract and household labour shows that when plots are not equipped with a motor pump, sharecropping leads to a higher profit than household labour does if the sharecropper's wage is nearly equal to the household wage. When plots are irrigated with a motor pump, sharecropping can provide a higher profit than household labour does, but only if the household wage is much higher than the sharecropper's wage.

Considering the average market wage rate for unskilled workers, the finding suggests that the optimum profit derived from plots under a wage labour contract is lower than that under household labour. However, the household wage above which hiring wage labour is more profitable than using only household labour, is lower when the plot is equipped with a motor pump. This means that horticultural households would have more incentives to hire wage labour if they could find a higher wage on the labour market and if they were better equipped.

The test of the efficiency of the inputs indicates that, on average, controlling for crop, the input fertilizer is used inefficiently, both on plots without a motor pump and those with a motor pump, although the latter generally exhibit higher efficiency scores. Controlling for crop and labour, the findings also suggest that the input is used as inefficiently on plots under household labour as on plots under a sharecropping contract or a wage labour contract. Consequently, this empirical evidence challenges the Marshallian common wisdom that connects sharecropping to inefficiency.

To sum up, these findings provide a better understanding of the reasons behind the existence and perpetuation of sharecropping over time and over developing countries like Senegal. The findings sketch the trend or the dynamic of the labour contract in a context of mechanization of the production. With the use of the motor pump, the future of the sharecropping arrangement is threatened in favour of the wage labour contract, unless the sharing terms for the landowner change. These findings complement the existing knowledge on labour arrangements provided by many empirical studies (Stiglitz, 1989; Ray 1998; Ghatak and Pandey, 2000; Otsuka and Hayami, 1988; Canjels, 1996). These findings call for some policy implications. Most of all, an improvement of irrigation equipment is urgently required, not only to make the production system less labour-intensive, but also to enable large-scale production and to improve the economic performance. Actually, the plots, and particularly those under household labour, are mostly very small. They often are under the optimum size, mainly because of labour and water constraints rather than land availability. Good agricultural programmes should be able to address these constraints and to lead to key achievements if designed and implemented successfully.

Chapter 5.

Risk Attitude and its Effect on Resource Allocation

5.1. Introduction

Risk can be defined as uncertain consequences or an exposure to potentially unfavourable circumstances (Smith *et al.*, 1999). By definition, risk is something undesirable (Smith *et al.*, 1999). Risk is different from uncertainty, which reflects an imperfection in knowledge without any particular value assessment about the consequences. While the probability of the distribution of outcomes related to risky prospects is known, that related to uncertain prospects is unknown and unquantifiable, unless subjectively. Risk is related to an action and is the chance of winning or losing, usually measured in terms of probability or variance (Roumasset *et al.*, 1979).

Agricultural production typically constitutes a risky business. Farm households face a variety of risks. Among them, Newbery and Stiglitz (1981) have distinguished two main categories:

- A production risk due to weather variability, pests and diseases, other environmental hazards such as inundation, drought, hurricanes, frost, et cetera;
- A price risk, particularly regarding the output price, which impacts upon the producer's decision making and income.

Most agricultural economists would agree that the producers' attitude towards risk determines their decision making, particularly in developing countries characterized by a high risk, a low income, and few risk-spreading options (Newbery and Stiglitz, 1981). Not only is the risk higher in poor rural economies, affecting farm households in several and profound ways, but poor farm households also lack the possibilities to deal with risk (Fafchamps, 2003). With limited access to credit and insurance markets, it becomes difficult to manage or cope with risk efficiently. While some wealthy households can find strategies to cope with risk and its consequences, like income volatility, through the use of their savings or through borrowing money, poor farm households only have recourse to defensive portfolio strategies to smooth their income and assets (van den Berg *et al.*, 2009).

Attitudes towards risk may not only be caused by poverty, but may contribute to maintain and emphasize poverty as well. As analysed by Morduch (1994), households may sacrifice their expected income in order to cope with risk through, for instance, a diversification of their crops or activities even if these are less profitable, but at least more free of risk. Such coping strategies provide short-term protection at a long-term cost (Abreha, 2007). To cope with risk, low-income households would opt for satisfying their current consumption by selling their productive assets and, consequently, by forgoing their expected future income. Such inappropriate or inefficient risk-coping strategies may lead to chronic or persistent poverty and an increase in the households' vulnerability. A producer's attitude toward risk and coping strategies should be a serious concern for poverty alleviation and economic development, particularly in developing countries.

Extensive research has shown that farmers are risk averse (Binswanger, 1980; Rosenzweig and Binswanger, 1993; Smith *et al*., 1999; Senkondo, 2000; Kumbhakar, 2002; Gomez-Limon *et al.*, 2002; Fafchamps, 2003; Just and Pope, 2003; Wick *et al*., 2004; Brons, 2005; Simtowe, 2006; Abreha, 2007; van den Berg *et al.*, 2009). These studies attempted to explain risk attitudes from individual socio-economic characteristics, such as wealth or income, family size, education, age, and gender. There is a mixture of evidence on the relationship between risk behaviour and these variables. Especially with regard to gender, while Binswanger (1980), Senkondo (2000), Simtowe (2006), and Cramer *et al.* (2002) have found that it does not significantly affect risk attitude, other authors (Wick *et al.*, 2004; Brons, 2005; Senkondo, 2000; Croson and Gneezy, 2008; and Borghans *et al.*, 2009) have found that women are more risk averse than men. Croson and Gneezy (2008) have tried to explain the gender difference in risk behaviour by the gender dissimilarity in emotional reaction, in overconfidence, and in the interpretation of the risk as a challenge or a threat. Accordingly, gender and risk aversion remain an interesting research issue.

Methodologies used to provide empirical evidence of individuals' risk attitudes can be classified into two main categories: econometric and experimental approaches. The econometric approach, mainly based on utility function or expected utility maximization, is criticized for overestimating risk aversion, confounding risk behaviour with other determinants, such as the resource constraints faced by decision makers (Wick *et al.*, 2004; Just and Pope, 2005). This is particularly important in developing countries that are characterised by imperfect markets and, as a result, by the non-separability of production and consumption decisions (Sadoulet and de Janvry, 1995; Wick *et al*., 2004). For these reasons, in this study, we adopted the experimental approach to elicit the producer's attitude toward risk. The experimental approach is rooted in hypothetical questions regarding risk alternatives or risky games with or without real monetary payoffs (Binswanger, 1980; Wick *et al*., 2004; Brons, 2005). Obviously, for any approach, one must be careful about interpreting agricultural choices or decision making as strong evidence that risk aversion is the primary explanation. To better understand the magnitude and implications of risk aversion, attention must be paid to the technical, physical, social, and financial structure of agricultural production and the inter-temporal dependence of income shocks and marginal utilities (Just and Pope, 2003).

In sum, attitudes toward risk are an important issue associated with farm households' behaviour, and may affect farm performance. Particularly in Senegal, for horticultural households, the market or output price is a major risk due to its high volatility. Although there is extensive theoretical literature on output price risk, the empirical evidence is relatively scarce (contrary to that regarding production risk, which is the subject of many empirical studies, (Kumbahar, 2002)). Furthermore, risk attitude may be considered as an individual characteristic. Within a household, the risk attitude may differ between the husband and wives who are managers of their separate plots, and this may have consequences for the efficient distribution of inputs among them. In addition, the optimal choices of input levels may differ, even if the underlying technology would be the same. In terms of labour, while some horticultural households rely on household labour, others have recourse to hired labour based on a sharecropping contract or a wage contract. The decision making with regard to the labour choice may be determined by risk attitudes.

As mentioned by Fafchamps (2003), in the context of developing countries, theory on risk behaviour is much more advanced than empirical work is. The scientific significance of this research is not only to contribute to the body of empirical evidence, but also to contribute to the reinforcement of the theoretical literature about risk attitudes. For this reason, this research aims to provide both theoretical and empirical evidence of measures and effects of risk attitudes, distinguished by gender. More precisely, this research endeavours to investigate the causal relationship between producers' risk attitude, the indicators of performance, and the decisions made regarding the choice of input and labour contracts, controlling for other exogenous characteristics such as age, education, gender, wealth, location, et cetera.

We will use an experimental method to address the following research questions:

- Do risk preferences differ between husband and wives, and between male and female heads of the household?
- If so, how are they related to individual characteristics, and what are the consequences for the household's economic performance, and particularly for the allocative efficiency of input choice?
- What are the effects of the risk attitude on the choice of labour contracts?

The results show that, on average, men and women producers display absolute risk aversion towards the output market price, and that women are as risk averse as men. As expected, and in line with the theoretical model, the empirical evidence shows that the allocative inefficiency in the use of inputs increases with risk aversion. Moreover, the empirical evidence confirms the theoretical model's assumption that if producers are more risk averse, they will prefer to hire labour based on a sharecropping contract rather than on a wage contract.

After the presentation of the background, the research objectives and questions, and the main findings through this introduction, the remainder of the chapter is structured as follows. The next section will present the methodology and more specifically the experimental procedure and the theoretical models used to measure risk aversion. We will also discuss the effects of risk aversion on the choice of inputs and labour contract. Then the empirical results and the discussion will follow. Finally, the conclusion and policy implications will ensue.

5.2. The experimental design and procedure

The research method is based on a large survey and the implementation of an experiment to measure the risk attitude of men and women or husband and wives plot managers within the same household. A total of 285 plot managers, including 186 men and 99 women from 203 households, have been surveyed in Senegal's Niayes Zone. The survey was conducted through a gender approach including both men and women and through a procedure, including:

1) the identification and classification of different types of risk faced by men and women plot managers within horticultural households;

2) the measurement of the incidence of each source of risk, using an index measure of incidence developed by Smith *et al.* (1999) to capture the breadth of the risk, or the proportion affected within the sample of horticultural households under study;
3) an assessment of the severity of the risks (Smith *et al.*, 1999) confronting horticultural households by using a ranking;
4) the setting of the probability of occurrence of each risk or the number of horticultural seasons for which the risk occurs and its consequences for horticultural households;
5) an appreciation of the predictability of the output market prices and of the possibility to make predictions for next month, given the current output market price.

After the completion of the questionnaire, the experimental game of the measurement of risk attitude towards the output market price was implemented separately for each man and woman plot manager within the household, to avoid any influence between household members. Given the current range of output market prices in the village or surrounding zone, and given the horticultural crop currently in production in the field, we presented a “risky market A” with uncertain output prices of P_{A1} and P_{A2}. P_{A1} is the low uncertain output price and P_{A2} the high one; each output price has a probability of occurrence of 50%, like a standard gamble. This was explained to the respondents as being similar to tossing a coin (head or tail). Another alternative “risk-free market B” was defined, with a certain price of P_{Bi}, varying between P_{A1} and P_{A2} ($P_{A1} < P_{Bi} < P_{A2}$). Then, we asked the producers on which of the two markets they would prefer to sell their production if they were to harvest it today. The game started with either a high or a low price P_{Bi} and accordingly, the certain price P_{Bi} was gradually lowered or increased until the plot manager became indifferent or switched from risky market A (uncertain prices P_{A1} and P_{A2}) to risk-free market B (certain price P_{Bi}), or the other way round. The output price P_{Bi} at which the producer becomes indifferent or switches from one market to another corresponds to the certainty equivalent price P_E of the respondent.

The objective was to implement a real game with real payment, but due to the limited research budget, this was not possible. Nevertheless, lots of efforts were made to bring producers to imagining themselves as being in a real situation, so that one could suppose the same results would come up if there would be any real payment. The producers showed great interest and understanding; they thoroughly enjoyed the experiment, which they found very innovative.

5.3. The theoretical model

5.3.1. Modelling risk attitude

Within horticultural households, men and women plot managers face an output market price risk. When producing, neither the men nor the women can predict perfectly at what price they will sell their crop after harvesting. The market price fluctuates a lot and impacts upon the horticultural revenue. Even if the yield per hectare achieved is high, if the output market price is low, the revenue derived from the production will be low, too.

Considering the experiment we did with two alternative markets:

- Risky market A with uncertain output prices P_{A1}, with a probability of occurrence 1- α and output prices P_{A2}, with a probability of occurrence α
- Market B, free of risk, with a certain output price P_B with a probability of occurrence 1.

Following the method of Newbery and Stiglitz (1981) and Cramer *et al*. (2002), the expected utility of the producer when choosing certain market B or uncertain market A is given as:

$$E(U_B) = U(P_B) \tag{5.1}$$

$$E(U_A) = \alpha U(P_{A2}) + (1-\alpha)U(P_{A1})$$
$$E(U_A) = \alpha U[P_B + (P_{A2} - P_B)] + (1-\alpha)U[P_B - (P_B - P_{A1})]$$

where U is the utility function of wealth and P_{A2} - P_B is the additional benefit won when the producer chose to sell the production on risky market A and was lucky to get the high output price P_{A2}, whereas P_B - P_{A1} is the loss when the producer got the low price P_{A1}.

The second-order Taylor series approximation gives:

$$\begin{aligned} E(U_A) &= U(P_B) + [\alpha(P_{A2} - P_B) - (1-\alpha)(P_B - P_{A1})]U'(P_B) + \\ &1/2[\alpha(P_{A2} - P_B)^2 + (1-\alpha)(P_B - P_{A1})^2]U''(P_B) \end{aligned} \tag{5.2}$$

At the equivalent output price P_E from which the producer is willing to shift from uncertain market A to certain market B or vice-versa, the expected utility of the uncertain output market price $E(U_A)$ is equal to the utility of the certain or risk-free output market price $U(P_E)$, so that equation 5.2 becomes:

$$U(P_E) = U(P_E) + [\alpha(P_{A2} - P_E) - (1-\alpha)(P_E - P_{A1})]U'(P_E) + \\ 1/2[\alpha(P_{A2} - P_E)^2 + (1-\alpha)(P_E - P_{A1})^2]U''(P_E) \tag{5.3}$$

So,

$$[\alpha(P_{A2} - P_E) - (1-\alpha)(P_E - P_{A1})]U'(P_E) + 1/2[\alpha(P_{A2} - P_E)^2 + (1-\alpha)(P_E - P_{A1})^2]U''(P_E) = 0$$

As defined by Arrow (1965) and Pratt (1964), two types of risk can be distinguished: absolute risk aversion (R_A) and relative risk aversion (R_R), defined as follows:

$$R_A = -\frac{U''}{U'} \\ R_R = -P_E\frac{U''}{U'} = P_E R_A \tag{5.4}$$

where P_E is the certainty equivalent price. Considering the experiment, α was set to ½, then the risk aversion scores can be deduced as follows:

$$R_A = -\frac{U''(P_E)}{U'(P_E)} = \frac{(P_{A2} + P_{A1} - 2P_E)}{\frac{1}{2}\left[P_{A2}^{\ 2} + P_{A1}^{\ 2} - 2P_E(P_{A2} + P_{A1}) + 2P_E^{\ 2}\right]} \tag{5.5}$$

$$R_R = -P_E\frac{U''(P_E)}{U'(P_E)} = \frac{P_E(P_{A2} + P_{A1} - 2P_E)}{\frac{1}{2}\left[P_{A2}^{\ 2} + P_{A1}^{\ 2} - 2P_E(P_{A2} + P_{A1}) + 2P_E^{\ 2}\right]}$$

The first hypothesis tested is whether or not men and women horticultural plot managers within the household behave differently towards the output market price risk. The review of the literature shows controversial evidence about gender and risk attitude.

5.3.2. Modelling the effect of risk on the efficiency of the choice of inputs and labour

Suppose that the choice of the level of input used for production is a function of the attitude toward risk. When producing, the input price is known but such is not the case for the output price. Producers then use the input, given the uncertainty of the output market price. In this way, it might turn out that producers with a higher risk aversion use less input than less risk averse producers. Accordingly, risk aversion may have an effect on the marginal value product of the input, which should equal to the input price if allocative efficiency holds. Therefore, we conjecture that more risk averse producers are less allocatively efficient.

Based on the conventional concept of allocative efficiency, there is a non-risky efficient level of input use or an optimal level of input use for a risk-neutral landowner and this is considered as the benchmark for efficiency. However, it may be also optimal for risk averse producers to use less input when the output market prices fluctuate. Some economists would argue that these risk averse producers who choose to use less inputs are efficient, too. The traditional concept of allocative efficiency assumes certainty. Under uncertainty, the traditional measure may no longer be appropriate. We may posit that allocative efficiency should reflect risk aversion.

Consider a male or female producer with a profit π derived from horticultural production, specified as follows:

$$\pi = \theta P_Y f(X, L) - wL - P_X X \tag{5.6}$$

Where P_Y is the output price, f is the output, which is a function of input X and labour L, w is the household labour opportunity cost, P_X is the input price, and θ is the random variable associated with the output price risk, with an expected value one and variance σ^2 ($E\theta=1$ and $Var\theta= \sigma^2$).

The objective of the producer is to maximize the expected utility of profit $EU(\pi)$, defined as:

$$\text{Max}\, EU[\theta P_Y f(X, L) - wL - P_X X] \tag{5.7}$$

The producer has to optimize production, by choosing an amount of input X, so that:

$$\frac{\partial EU(\pi)}{\partial X} = 0$$
$$\Leftrightarrow E\{U'[\theta P_Y f(X, L) - wL - P_X X][\theta P_Y f_x^{'} - P_X]\} = 0 \qquad (5.8)$$
$$\Leftrightarrow EU'(\pi)\theta P_Y f_X^{'} = EU'(\pi)P_X$$

As P_X, P_Y and f_X' are non-random, the equation becomes:

$$P_Y f_X^{'} EU'(\pi)\theta = P_X EU'(\pi)$$
$$\Leftrightarrow \frac{P_Y f_X^{'}}{P_X} = \frac{EU'(\pi)}{EU'(\pi)\theta} \qquad (5.9)$$

The left-hand side of the equation corresponds to the ratio marginal value product of input X and its price, and this corresponds to the measured indicator of allocative efficiency. The right-hand side is the ratio of the expected marginal utility of the profit over the expected marginal utility of the random profit. So, the equation establishes the relationships between the producer's allocative efficiency and the marginal utility of the expected random profit.

Furthermore, by a first-order approximation of θ around 1, it follows:

$$U'(\pi)\theta \approx \left[U'(\pi)\theta\right]\Big|_{\theta=1} + (\theta-1)[U'(\pi) + \theta U''(\pi).P_Y f]_{\theta=1} + \tfrac{1}{2}(\theta-1)^2[U''(\pi)P_Y f +$$
$$U''(\pi).P_Y f + \theta U''(\pi)(P_Y f)^2]_{\theta=1}$$

and ignoring the third – order derivative $E[U'(\pi)\theta] = U'(\bar{\pi}) + \sigma^2 U''(\bar{\pi})P_Y f$ (5.10)

With the variance σ2 equal to:

$$\sigma^2 = E(\theta-1)^2 = E\theta^2 - 2\theta + 1 = E\theta^2 - 1$$

Then

$$EU'(\pi) = U_1^{'} + E[(\theta-1)^2 U''(\pi)] = U'(\pi)$$

Knowing EU'(π) and EU'(π)θ, equation 5.9 can be written as:

$$\frac{P_Y f_X^{'}}{P_X} = \frac{EU'(\pi)}{EU'(\pi)\theta} \approx \frac{U'(\overline{\pi})}{U'(\overline{\pi}) + U''(\overline{\pi})P_Y f\sigma^2} \tag{5.11}$$

Knowing the producer's risk attitude, defined by the absolute risk aversion score R_A:

$$R_A = -\frac{U''}{U'} \Leftrightarrow U'' = -U' R_A$$

Replacing U" by its value gives:

$$\begin{aligned} \frac{P_Y f_X^{'}}{P_X} &= \frac{U'(\overline{\pi})}{U'(\overline{\pi}) - U'(\overline{\pi})R_A P_Y f\sigma_\theta^2} \\ \Leftrightarrow \frac{P_Y f_X^{'}}{P_X} &= \frac{1}{1 - R_A P_Y f\sigma_\theta^2} \end{aligned} \tag{5.12}$$

As the relative risk aversion R_R is related to the random part of the revenues only, it is:

$$R_R = P_Y f R_A$$

Then :

$$\frac{P_Y f_X^{'}}{P_X} = \frac{1}{1 - R_A P_Y f\sigma_\theta^2} = \frac{1}{1 - R_R\sigma_\theta^2} \tag{5.13}$$

This equation suggests that an allocative efficiency of inputs is a function of the producer's risk aversion and the variance σ_θ^2 of the random variable θ associated with output market price risk.

If

$$\sigma_\theta^2 = 0 \Rightarrow \frac{P_Y f_X^{'}}{P_X} = 1 \Rightarrow f_X^{'} = \frac{P_X}{P_Y} \Rightarrow X = X^* \tag{5.14}$$

then, producers choose the input in such a way that its marginal value product over input price, which corresponds to the efficiency rate is equal to unity. This means that, in this case, producers are fully allocatively efficient. The marginal product of input is equal to the ratio input price over output price. This means that producers choose the optimum amount of input X*.

For the risk averse producers, R_A and R_R are positive. In addition, if the expected utility function U(π) is a Von Neumann-Morgenstern utility function U''(π)<0, and σ_θ^2 is positive, then it follows:

$$\sigma_\theta^2 R_R > 0 \Leftrightarrow 1-\sigma_\theta^2 R_R < 1 \Leftrightarrow \frac{1}{1-\sigma_\theta^2 R_R} > 1 \Leftrightarrow \frac{P_Y f_X^{'}}{P_X} > 1 \Leftrightarrow f_X^{'} > \frac{P_X}{P_Y} \Rightarrow X < X^* \tag{5.15}$$

Consequently, risk averse producers are allocatively inefficient, which means they use sub-optimally low levels of input. When R_A or R_R increases, the allocative inefficiency increases as well. In other words, the greater the risk aversion score is, the greater the allocative inefficiency is, too. On the other hand, for producers who are risk lovers, R_A and R_R are negative. In that case, it follows that they are allocatively inefficient and they overuse the input, which means that they use it at a level greater than the optimum one. Only risk-neutral producers (R_A and R_R are equal to zero) are fully allocatively efficient. They use the input at the optimum level to equalize the marginal value product to the unit input price.

The same theory holds for the labour input, for which the relationships between allocative efficiency and risk aversion can be specified as follows:

$$\frac{P_Y f'}{w} = \frac{1}{1-\sigma_\theta^2 R_R} \tag{5.16}$$

The second hypothesis tested is that more risk averse producers allocate their inputs (fertilizers, seeds, pesticides) and labour less efficiently.

5.3.3. Modelling the effect of risk on the choice of labour contract

We suppose that men and women producers who are risk averse are more willing to hire labour based on a sharecropping contract than labour based on a wage contract, or to use household labour. The terms of the sharecropping contract and particularly the sharing rules are fixed and defined before the start of the production. On a contract based on wage labour, the wage to pay is known at the beginning of the production. The wage rate is fixed whatever the result of the production and, consequently, whatever the output market price (which is uncertain). Contrary, under a sharecropping contract, the producer landowner has to pay a share of the expected profit to the tenant, given the uncertainty of the output market price. Thus, both the landlord and the tenant share the output market price risk.

Under a sharecropping contract, the producer/landlord's expected profit can be specified as:

$$\pi_s = (1-\beta)[\theta P_Y f_s^*(L_s^*, X_s) - P_X X_s] \qquad (5.17)$$

while the tenant's or sharecropper's expected profit is:

$$\pi_t = \beta[\theta P_Y f_s(L_s, X_s) - P_X X_s] + w_o L_o \text{ subject to } L = L_s + L_o \qquad (5.18)$$

where 1-β and β stand for the respective share of the profit expected by the producer/landlord and the tenant, f_s is the expected production, which is a function of the input Xs and labour Ls, P_Y is the expected output market price, P_X is the input price, and L is the tenant's total labour endowment, with Ls being labour allocated to sharecropping, and Lo being labour allocated to other off-farm work at a wage rate w_o.

The sharecropper's objective is to maximize his expected utility of profit, in order to equate the marginal utility of the extra income (given by β times the marginal value product) to the marginal utility of the wage rate in alternative employment. His objective can be defined as follows:

$$MaxEU(\pi_t) = MaxE\{U[\beta[\theta P_Y f_s(L_s, X_s) - P_X X_s] + w_o(L - L_s)]\} \qquad (5.19)$$

The first-order conditions with respect to labour Ls are:

$$\begin{aligned} &E\{U'[\beta[\theta P_Y f_s(L_s, X_s) - P_X X_s] + w_o(L - L_s)][\beta\theta P_Y f_{sl}^{'}(L_s, X_s) - w_o]\} = 0 \\ &\Leftrightarrow EU'(\pi_t)\beta\theta P_Y f_{sl}^{'}(L_s, X_s) - EU'(\pi_t)w_o = 0 \\ &\Leftrightarrow \beta P_Y f_{sl}^{'} EU'(\pi_t)\theta - w_o EU'(\pi_t) = 0 \end{aligned} \qquad (5.20)$$

and L_s is implicitly defined by

$$P_Y f_{sl}^{'} = \frac{w_0 / \beta}{(1 - R_t \sigma_\theta^2)}$$

R_t is the relative risk aversion coefficient of the sharecropper.

When the landowner/manager hires labour under sharecropping, given the uncertainty of the output market price, he/she would decide on providing the inputs X so as to maximize the expected utility of profit EU(π_s), which is defined as follows:

$$MaxEU(\pi_s) = MaxE\{U[(1-\beta)[\theta P_Y f_s(L_s, X_s) - P_X X_s]]\} \quad (5.21)$$

In this process, the responses of the sharecropper to changes in *X* are taken into account. The optimal levels depend, therefore, on the sensitivity of the worker's marginal product to changes in *X*, which is given by the cross-derivative of f_s with respect to L_s and *X*.

The first-order condition for the optimal input of X is

$$P_Y f'_{sX} = \frac{P_X}{1 - R_S \sigma_\theta^2} + \frac{f''_{slX}}{f''_{sll}} \frac{w_0 / \beta}{1 - R_t \sigma_\theta^2} \quad (5.22)$$

The first term on the right-hand side (RHS) shows the adjustment of the price by the risk factor: the higher the plot manager's relative risk aversion (R_S), the higher the effective price that the marginal value product is compared with. The second term shows the effect of the worker's adjustment to more inputs. Typically, this term is negative, thus inducing a lower optimal value for the marginal product of X and more use of X.

We elaborate this for the case of a Cobb-Douglas production function. Dropping the suffix *s*, this function is:

$$f = f(L, X) = aL^\lambda X^\gamma \quad (5.23)$$

The optimal input of a sharecropper's time, as a function of X, is then

$$L^* = \left[\frac{w_0 / \beta}{1 - R_t \sigma_\theta^2} X^{-\gamma} \frac{1}{\lambda a P} \right]^{\frac{-1}{1-\lambda}} \quad (5.24)$$

and the plot manager's optimization problem $\max EU[(1-\beta)(\theta P_Y f(L^*, X) - P_X X)]$ has as first-order condition for X

$$P_Y \frac{df}{dX} = \frac{P_X}{1 - R\sigma_\theta^2}, \tag{5.25}$$

where R is the plot manager's relative risk aversion coefficient. In the Cobb-Douglas case, and with the above expression for L, this leads to an optimal use of X given by

$$X^* = \left(\frac{P_X (1-\lambda)}{(1 - R\sigma_\theta^2)\gamma} \right)^{-\frac{1-\lambda}{n}} (aP)^{\frac{1}{n}} \left(\frac{w_0 / \beta}{\lambda (1 - R_t \sigma_\theta^2)} \right)^{-\frac{\lambda}{n}}, \text{ where } n = 1 - \gamma - \lambda. \tag{5.26}$$

The expression shows how the effective price of X is increased by risk aversion, but 'decreased' by the effect on the sharecropper's labour input, given by the factor $(1-\lambda)$. The sharecropper's effective wage is enhanced by risk aversion and by the share β.

To simplify the expression, denote:

$$v_s = \frac{1 - R\sigma_\theta^2}{1-\lambda}, v_t = 1 - R_t \sigma_\theta^2, v_w = 1 - R\sigma_\theta^2$$

With the optimal input of X, and the concomitant input of L by the sharecropper, the expected level of profits is given by the following expression.

$$\pi_s = (1-\beta)(aP_Y)^{\frac{1}{n}} \left(\frac{P_X}{\gamma v_s} \right)^{-\frac{\gamma}{n}} \left(\frac{w_0 / \beta}{\lambda v_t} \right)^{-\frac{\lambda}{n}} (1 - \gamma v_s) \tag{5.27}$$

To show how the choice for sharecropping depends on risk aversion, we can compare this level of expected profits with the level for wage labour contracts.

Under a wage labour contract, when paying a wage rate w to the hired labourer, the producer would expect a profit π_w, defined as:

$$\pi_w = [\theta P_Y f_w(L_w, X_w) - P_X X_w - wL_w] \qquad (5.28)$$

Given the uncertainty of the output market price, when hiring wage labour, the producer maximizes the expected utility of profit EU(π_w), defined as

$$MaxEU(\pi_w) = MaxE\{U[\theta P_Y f_w(L_w, X_w) - P_X X_w - wL_w]\} \qquad (5.29)$$

The optimal choice of labour and inputs leads to the following expression for the expected profits under a wage labour contract

$$\pi_w = (aP_Y)^{\frac{1}{n}} \left(\frac{P_X}{\gamma v_w}\right)^{-\frac{\gamma}{n}} \left(\frac{w}{\lambda v_w}\right)^{-\frac{\lambda}{n}} [1 - (\lambda + \gamma)v_w] \qquad (5.30)$$

The differences between (5.30) and (5.27) are in the roles of v_s and v_w, which differ by a factor (1-λ) in the effective wages (w/v_w for wage workers, and $w_0/\beta/v_t$ for sharecroppers) and in the overall reduction factors.

The question now is how any choice between hiring workers as sharecroppers or as wage workers depends on the risk aversion of the plot manager. Note that the plot manager's risk aversion has an impact on the amount of labour hired under the wage contract, but not under the sharecropping contract, as in this case the choice is made by the sharecropper. In both cases, the choice of the inputs X is dependent on the risk aversion, and in the case of sharecropping, this effect is mitigated by the indirect effect on the sharecropper's labour input. This is why we defined the v_s, incorporating the factor (1-λ), in the denominator.

Relative levels of profit under both types of contract will depend on the behaviour of the sharecropper (his opportunity costs and risk aversion), on the share, and on the parameters. The effect of a change in the plot manager's risk aversion on the choice of labour contract can therefore not be directly seen from the profit functions themselves.

We can, however, derive the effect by looking at how profit levels respond to changes in the plot manager's relative risk aversion R, holding constant the sharecropper's risk aversion R_t. If one type of profit is more responsive to changes in R than another type, we can expect there to be an effect on the choice of labour contract. For, if the variables would make the two profits equal, a change in risk aversion will tilt the balance in favour of one of them. In general, the effect of *R* on profits is negative: more risk aversion leads to lower profits. Thus, if an increase in *R* lowers the profits of wage contracts by more than profits under sharecropping contracts, this would mean that managers with a higher risk aversion are more inclined to go for sharecropping than for wage contracts.

The two expressions for the derivatives of profits with respect to *R* are:

for sharecropping:

$$\frac{d\pi_s}{dR} = -\gamma\pi_s\left(\frac{1}{nv_s} - \frac{1}{1-\gamma v_s}\right)\frac{\sigma_\theta^2}{1-\lambda} \tag{5.31}$$

and for wage contracts:

$$\frac{d\pi_w}{dR} = -(\gamma+\lambda)\pi_w\left(\frac{1}{nv_w} - \frac{1}{1-(\gamma+\lambda)v_w}\right)\sigma_\theta^2 \tag{5.32}$$

Figure 5.1 shows the behaviour of the two expressions over the profit for λ=0.5, γ=0.2 and σ_θ^2=0.2.

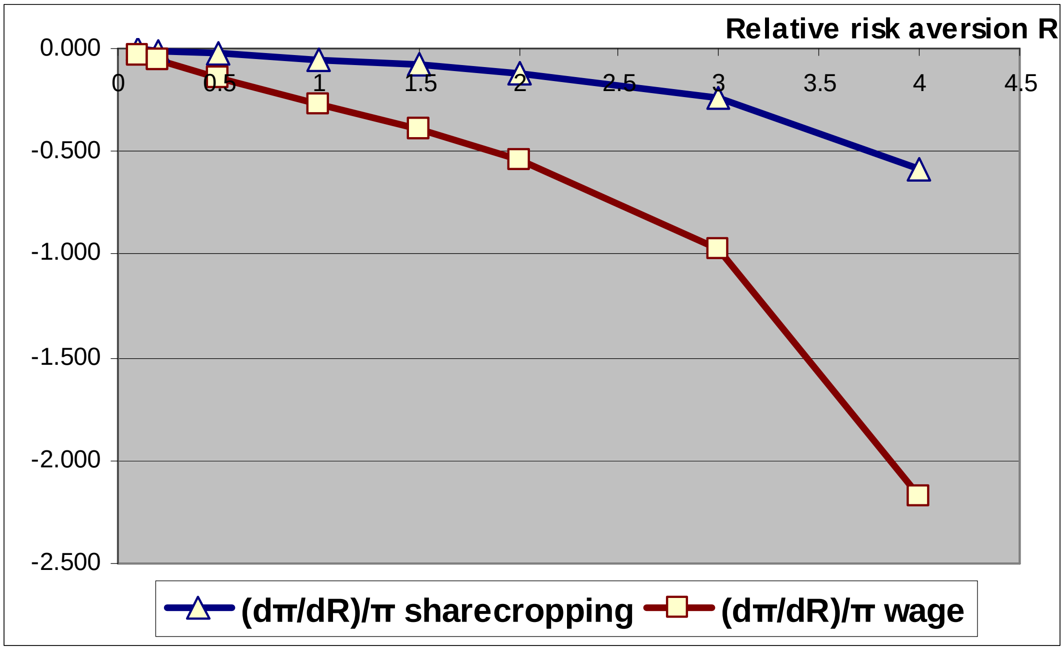


Figure 5.1: The fall in profits for unit changes in relative risk aversion coefficients.

As shown in figure 5.1, the (downward) sensitivity of the profits to an increase in risk aversion is greater under a wage contract than it is under a sharecropping contract. This result also holds for lower and higher values of λ or γ.

The conclusion is, therefore, that higher levels of risk aversion of the plot manager would favour a choice for sharecropping rather than wage contracts. This is the third hypothesis to be tested. Both under sharecropping and wage contracts, the choice of inputs X is dependent on the risk aversion. However, in the case of sharecropping, this effect is mitigated by the fact that the risk is shared between the plot manager/landowner and the sharecropper. For this reason, the plot manager may provide more inputs under a sharecropping arrangement than under a wage contract.

5.4. The empirical model and estimation

Modelling the effect of risk on the choice of inputs and labour

Following Zellner *et al*. (1966), as quoted by Kumbhakar (2002), we assume that the expected output price $\overline{P}_Y$ is equal to the observed output price P_Y, expressed as:

$$\overline{P}_Y = P_Y\theta \Leftrightarrow E(\overline{P}_Y) = P_Y E(\theta) = P_Y \text{ if } E(\theta)=1 \text{ and } Var(\theta)=\sigma. \tag{5.33}$$

Based on this assumption, knowing the producer's allocative inefficiency of inputs (derived from the gender-specific production functions of the previous Chapter 4), the effect of the output price risk on it can be tested, using the following function:

$$\frac{P_Y f_X^{'}}{P_X} - 1 = g(R_A, M, S, W, L) \tag{5.34}$$

where:

- M is the risk perception measured in terms of the appreciation of market price predictability;
- S is a vector of status, including the producer's socio-economic characteristics, such as the status of the head of household, the gender, age, education, number of wives, the women's status (first wife, second wife, et cetera), the access to credit and extension services, et cetera;
- W is a vector of wealth, including the men's annual income, the women's annual income, the share of the men's off-farm income, the share of the women's off-farm income, the household's labour endowment (or household size), the household's land endowment, the plot area cropped, et cetera;
- L is a vector of location: the north, centre, or south zone of Niayes.

Fully allocatively efficient producers choose the input in such a way that its marginal value product divided by input price, which corresponds to the efficiency rate is equal to one. Thus, the marginal value product of inputs divided by input price minus one (the left-hand side of equation 5.34) is used to capture the allocative inefficiency of inputs.

Modelling the effect of risk on the choice of labour contract

We used the binary choice (or univariate dichotomous) models to test the hypothesis that producers using sharecropping should have a higher risk aversion score compared to producers using wage labour or household labour,. These models describe the probability of choosing a sharecropping contract (Sh=1) rather than a wage contract or household labour (Sh=0), and also the probability of choosing a wage labour contract (Wg=1) instead of the alternative choices (Wg=0), depending on the man's or woman's risk attitude (R_A) and other individual characteristics (X). These models can be expressed as follows:

$$\begin{aligned} &P\{Sh = 1/R_A, X\} = F(R_A, \alpha; X, \beta) \\ &P\{Wg = 1/R_A, X\} = F(R_A, \chi; X, \delta) \end{aligned} \qquad (5.35)$$

where α and χ are the parameters to be estimated associated with risk attitude, respectively on the sharecropping contract and wage contract binary choice models, while β and δ are vectors of parameters associated with vectors of individual characteristics (X), hypothesized to affect the labour choice.

5.5. The empirical results

5.5.1. The identification of different risks and classification by order of severity

Risks faced by rural households in developing countries can be classified in four types:

- environmental hazards like drought, inundation, hurricanes, an earthquake, fire, a pest;
- the disease and death of people or livestock;
- business shocks like a change in the input and output prices, or an economic crisis;
- policy shocks like a conflict, a putsch, or war.

For men and women plot managers, the different risks faced in their horticultural activities were identified and prioritized by order of severity. The examination of the results shows that the first risk identified as the most severe by men and women plot managers is the output market price.

About 96% of the men and women identified the output market price as the most important risk they face. With the high fluctuation of the horticultural output market price, which is responsive to the supply and demand, when producing, male and female plot managers can never know for certain at which price they will be able to sell their production later on, after harvesting. Furthermore, the output price is one of the foremost key determinants of revenue. Therefore, one could understand why both men and women found the output market price the most severe risk they face when producing, since it can gravely decrease their revenue. With the free market, men and women plot managers are price-takers. Moreover, as horticultural products quickly perish, the absence of any means of storage and conservation, often immediately after harvesting, forces producers to sell their production automatically, whatever the market prices. If they have found a good output market price, they are lucky to achieve a good revenue and profit, but otherwise, the revenue will be low whatever the high level of yield realised.

The second most severe risk is the productivity (mainly of land and seed) identified and classified by 95% of the men and women plot managers. The third important risk is parasitism (plant diseases, locust invasions), identified by 57 % of the men and 42% of the women plot managers. A gender analysis shows that, for both men and women, the first three risks are the same. A gender difference occurs in the other risks identified. While women plot managers identified as other, secondary risks the irregularity of the water provision (for those connected to the Water Corporation - SDE) and wandering cattle, men found five other risks in addition, such as the climate (inundations due to an excess of rain), the perishable nature of horticultural product, the selling means (the availability of transport means such as freight for export), the crop choice, and the availability of sharecroppers. Table 5.1 presents the different risk identified and ranked by order of severity by men and women plot managers.

Table 5.1: The identification and prioritization, by order of severity, of different risks faced by plot managers across gender

Identified risks	Gender	Risk ranking by order of severity							
		1st risk		2nd risk		3rd risk		4th risk	
		Freq.	Percent	Freq.	Percent	Freq.	Percent	Freq.	Percent
Output market price	Men	161	96.99	3	1.83	2	7.14	0	0
	Women	74	96.10	3	4.05	0	0	0	0
Productivity	Men	2	1.20	157	95.73	5	17.86	0	0
	Women	2	2.60	71	95.95	1	14.29	0	0
Parasitism	Men	0	0	1	0.61	16	57.14	1	50
	Women	1	1.30	0	0	3	42.86	0	0
Water provision	Men	3	1.81	0	0	0	0	0	0
	Women	0	0	0	0	2	28.57	0	0
Perishable product	Men	0	0	1	0.61	0	0	0	0
	Women	0	0	0	0	0	0	0	0
Selling means	Men	0	0	1	0.61	0	0	0	0
	Women	0	0	0	0	0	0	0	0
Crop choice	Men	0	0	1	0.61	0	0	0	0
	Women	0	0	0	0	0	0	0	0
Climate	Men	0	0	0	0	4	14.29	0	0
	Women	0	0	0	0	0	0	0	0
Sharecroppers' availability	Men	0	0	0	0	1	3.57	0	0
	Women	.0	0	0	0	0	0	0	0
Wandering cattle	Men	0	0	0	0	0	0	1	50
	Women	0	0	0	0	1	14.29	0	0
Total	Men	166	100.00	164	100.00	28	100.00	2	100.00
	Women	77	100.00	74	100.00	7	100.00	0	0.00
	Overall	243	100.00	238	100.00	35	100.00	2	100.00

5.5.2. Measurement of risk occurrence

The risk occurrence is the number of horticultural seasons for which the risk occurs out of 10 seasons. For each risk, the occurrence was evaluated by male and female plot managers. The results are presented in table 5.2. The chance of an occurrence of the output market price risk varies from one to ten out of ten horticultural seasons. On average, for both men and women, the high volatility of output market price occurs seriously in 6 out of 10 seasons. The chance of an occurrence of the productivity risk is set to 3 by men and to 4 by women; it is almost similar to that of the parasitism risk (table 5.2).

Table 5.2: The chance of an occurrence of risk across gender

Types of risk	Plot manager's gender	Chance of risk occurring (number of seasons out of 10)		
		Mean	Min	Max
1. Output market price	Overall	5.97	1	10
	Men	6.10	1	10
	Women	5.70	1	9
2. Productivity	Overall	3.61	1	9
	Men	3.40	1	8
	Women	4.08	1	9
3. Parasitism	Overall	3.16	0	7
	Men	2.83	0	7
	Women	4.28	1	7

5.5.3. Measurement of the perception of the output market price risk

To measure the perception of the output market price risk, we asked men and women plot managers a series of questions about the predictability of the output market price and the annoyance caused by the output market price volatility.

Output market price predictability and annoyance

To the question "How do you assess the predictability of the market price?", about 80% of the men and 90% of the women replied "unpredictable" (table 5.3). This means that a vast majority of men and women perceived the output market price as a real risk. No woman found the output market price predictable, while more than 2% of the men found it predictable. Also, more men than women found the market price quite or a little bit predictable. Therefore, some gender difference can be noticed in terms of the appreciation of the output market price predictability and, subsequently, in terms of its perception as a real risk.

Table 5.3: The appreciation of the output market predictability by men and women plot managers

Output market price predictability	Frequency			Percent		
	Men	Women	Overall	Men	Women	Overall
Predictable	4	0	4	2.44	0	1.66
Quite predictable	30	8	38	18.29	10.39	15.77
Unpredictable	130	69	199	79.27	89.61	82.57
Total	164	77	241	100	100	100

Similarly, the vast majority of men and women strongly agreed that it is annoying, the way in which output prices can fluctuate. The percentages of men and women who strongly agreed are quite equivalent to those who found the output market price unpredictable (table 5.4). This shows again that the output market price is truly perceived as a risk. A pairwise correlation between the appreciation of the output market price predictability and the appreciation of the annoying output price fluctuation shows a coefficient of 0.13, significant at the 5% level.

Table 5.4: The annoying output market price fluctuation

Annoying output price fluctuation?	Frequency			Percent		
	Men	Women	Overall	Men	Women	Overall
Totally disagree	5	1	6	3	1	3
Disagree	9	0	9	5	0	4
Don’t care	9	4	13	6	5	5
Agree	10	5	15	6	7	6
Strongly agree	130	67	197	80	87	82
Total	163	77	240	100	100	100

The probability of predictions of the output market price

The results of the predictions of the output market price for next month, given the current market price (P), show that women are more optimistic (table 5.5). Women predict a higher probability of an increase of the output price (69%) compared to men (46%). The predictions change over time and crops. While from August to November, an increase in the output market price is predicted most often, from December to January, the probability of a decrease is greater. These predictions are realistic because the first period corresponds to the third horticultural season and coincides with the rainy season, in which the supply of horticultural products is very limited due to the unfavorable production conditions. The second period corresponds to the best season and, consequently, to market saturation and a low price. Except for November, the tendencies of the predictions of the output market price over time are roughly similar across gender.

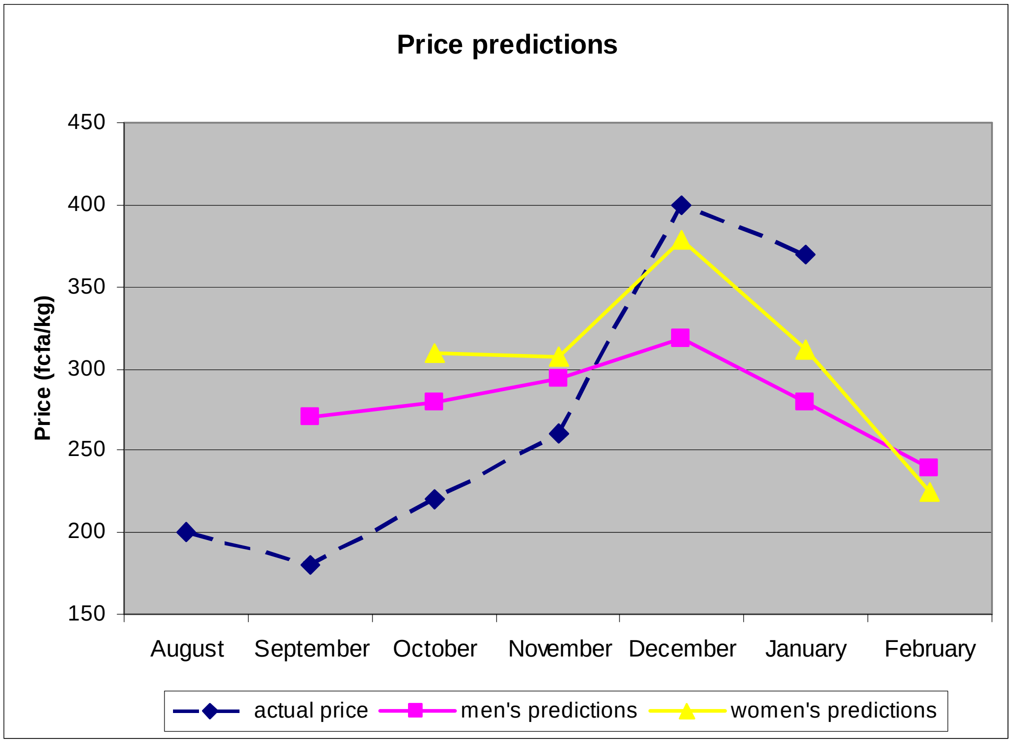
Table 5.5: Next month's predicted output price probability across gender and given the current output market price (P).

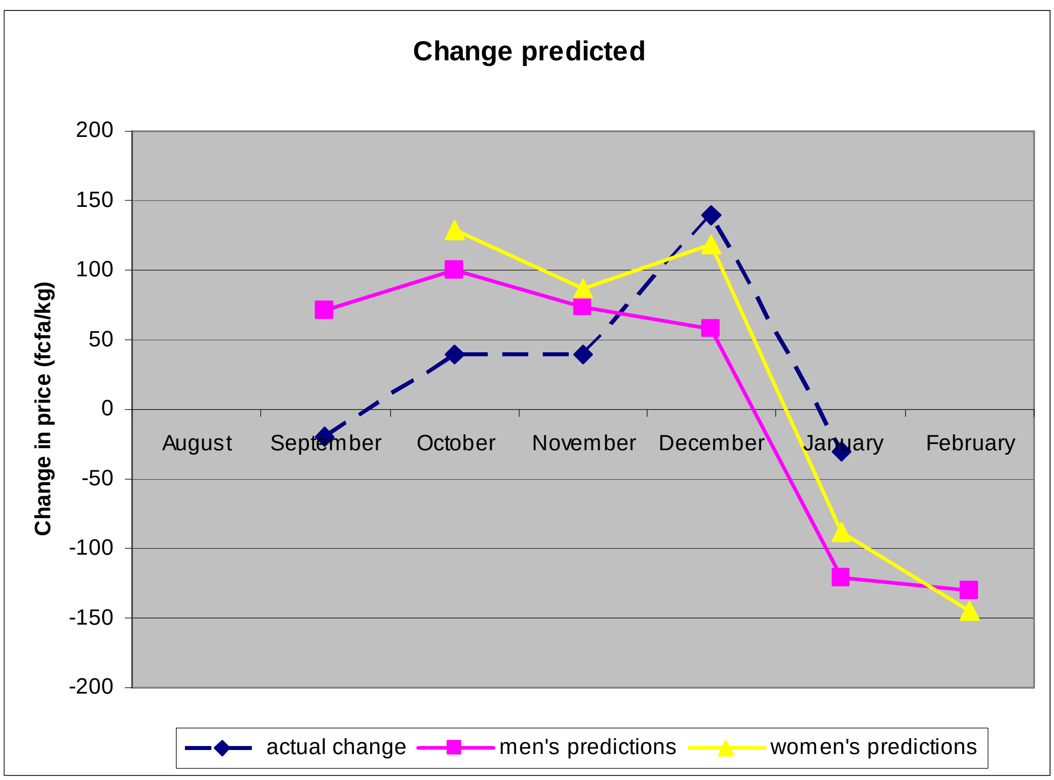
Plot manager's gender	Next month's price predicted	Next month's predicted price probability (%) [17]						
		Overall	August 2006	September 2006	October 2006	November 2006	December 2006	January 2007
Men	0.50 P	23	0	0	3	4	42	60
	0.75 P	18	0	1	4	18	37	32
	P	13	0	7	17	15	21	3
	1.25 P	19	58	28	33	25	0	1
	1.50 P	19	42	31	30	31	0	3
	2 P	8	0	33	13	7	0	1
	Total	100	100	100	100	100	100	100
Women	0.50 P	13		0	3	0	37	63
	0.75 P	8		0	2	0	22	31
	P	10		6	9	10	33	6
	1.25 P	27		14	39	17	8	0
	1.50 P	26		23	30	67	0	0
	2 P	16		57	17	7	0	0
	Total	100		100	100	100	100	100

Note: P=current output market price.

The series of graphs 5.2 shows the current market prices of horticultural crops and the predictions over time and gender. From the graphs, the high volatility of the output current market price can be seen from one month to the next. The predictions for the next month, given the current market price, vary also over months and gender. The graph reflects the difficulty to predict prices for next month. A gender comparison shows that, for overall crops, the curves of predictions made by women are closer to the current observed prices than those made by men. However, controlling for cabbage, the gender difference in predictions becomes small. Altogether, women seem to have a better ability to make price predictions than men have, although it remains hard for both. Because of their off-farm activity of small trading, women are more present in the market.

[17] The table shows the average predictions for all crops (mainly cabbage, tomato and turnip) which have similar output market prices. These crops are grown both by the men and the women.


Price predictions
450
400
350
300
250
200
150
Price (fcfa/kg)
August
September
October
November
December
January
February
actual price
men's predictions
women's predictions


Change predicted
200
150
100
50
0
-50
-100
-150
-200
Change in price (fcfa/kg)
August
September
October
November
December
January
February
actual change
men's predictions
women's predictions

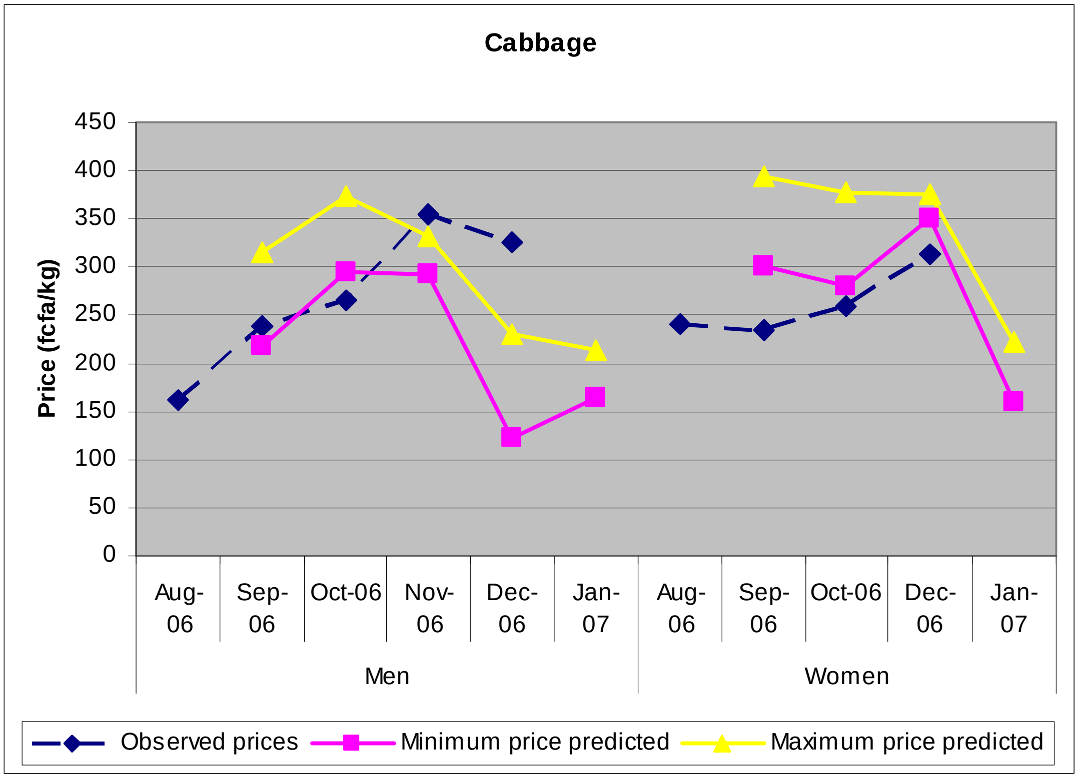
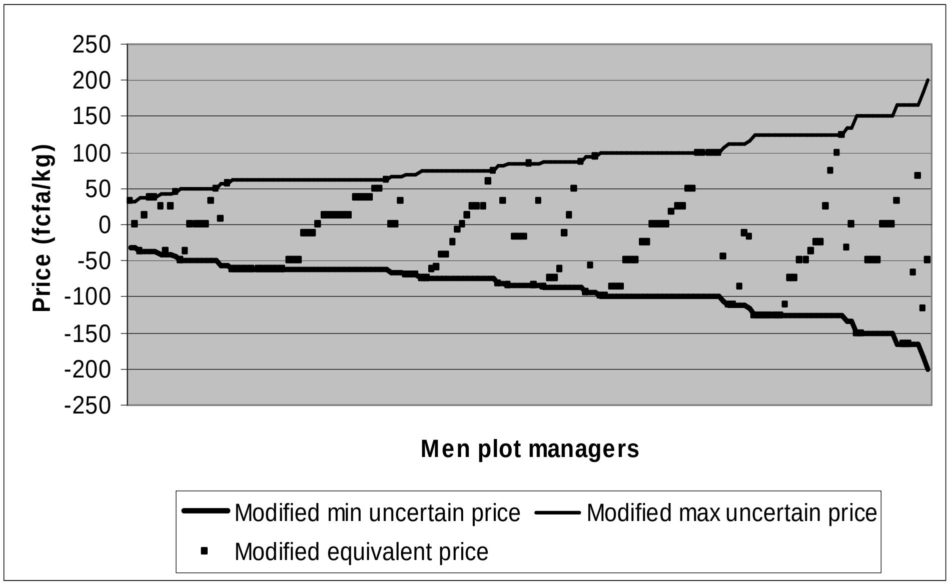


Figure 5.2: All crops and cabbage, observed market prices, average, minimum and maximum market prices predicted for next month, given the current prices.

5.5.4. Measurement of the risk attitude toward the output market price across gender

Certainty equivalent prices

An experimental game was implemented to measure men's and women's attitude toward the output market price risk, as described in detail in section 5.2. The output market price at which the producer becomes indifferent or switches from one market to another corresponds to the certainty equivalent price P_E of the respondent. The uncertain prices range on average from 208 to 400 fcfa/kg for men and from 221 to 422 fcfa/kg for women. The average equivalent prices of men and women are close and are, respectively, 277 and 307 fcfa/kg. Graph 5.3 depicts over gender the modified minimum and maximum prices of the risky market and the modified certainty equivalent price, measured in deviation of the mean of the minimum, maximum, and equivalent prices. For both men and women plot managers, some of the certainty equivalent prices show up below the X axis and others above it, showing a difference in risk attitude. The more risk averse have their certainty equivalent prices below the X axis and close to the minimum prices.



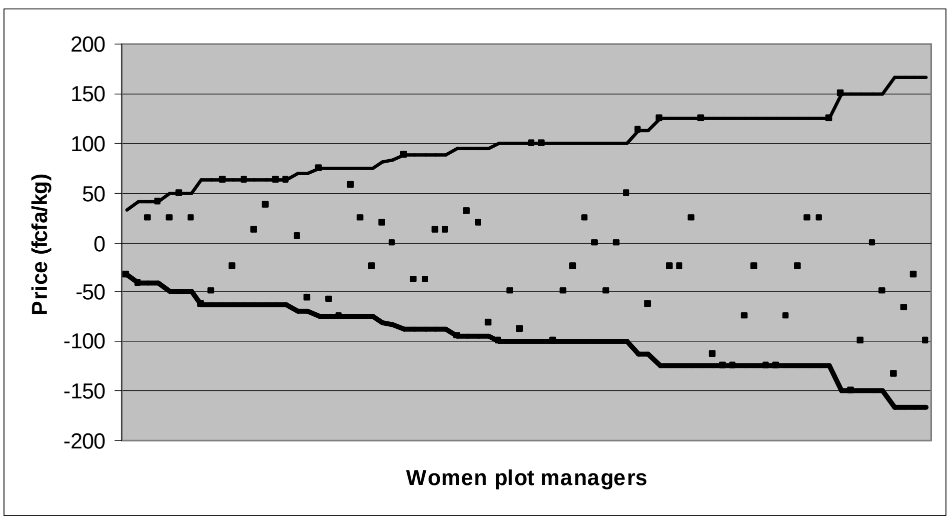


Figure 5.3: Modified minimum and maximum prices of the risky market and modified certainty equivalent prices over gender.

Risk aversion scores across gender

The absolute risk aversion scores (R_A) and relative risk aversion scores (R_R), derived from the equations 5.5, are presented in table 5.6. The results show that, on average, both men and women producers are risk averse, as shown by their positive risk aversion scores. The standard deviations are high, suggesting that absolute and relative risk aversion scores vary among men and women. Surprisingly, the men's risk aversion scores are greater than the women's, but the two groups' mean comparison t-test indicates that the difference is not significant even at the 10% level. This finding should not be too surprising. Indeed, women involved in horticultural production are used to going to the market to sell their own production, or through the small trading they are engaged in as an off-farm activity. For these reasons, women have as much knowledge about how the market operates as men have, and even more knowledge than men who sell their products at the field gate. This may explain why women are as risk averse as men towards the output market price.

This finding is in line with findings by Binswanger (1980) in India, Senkondo (2000) in Tanzania, and Van den Berg *et al*. (2008) in Nicaragua. They found no significant effect of gender on risk attitude, although these studies dealt with other types of risks, like risks in agroforestry decision-making, wealth, and environmental hazards. However, this finding challenges several authors, such as Kochar (1999), Byrnes *et al.* (1999), Wick *et al*. (2004), Brons (2005), Dohmen *et al*. (2005), Cohen *et al*. (2007), Croson and Gneezy (2008), and Borghans *et al.* (2009), who found that women are more risk averse than men. Croson and Gneezy (2008) have reviewed the experimental economics studies on the impact of gender on risk preference and have concluded that men are more risk-taking than women do. However, the studies reviewed by these authors are based on experiments realized mainly with students or a university population, carried out in European countries. Moreover, Croson and Gneezy (2008) have found from their review that managers and professional business persons are the exception to the rule that men take more risk than women do (quoting Atkinson *et al.* (2003), Johnson and Powell (1994), Master and Meier (1988)). From all these evidences we can conclude that there is no clear-cut relation between gender and risk attitude; the type of risk and the cultural, social, and economic context do matter a lot indeed.

Table 5.6: Risk aversion scores across gender.

Gender	Obs.	Absolute risk aversion scores (R_A)		Relative risk aversion scores (R_R)	
		Mean	Std. Dev	Mean	Std. Dev
Men	160	0.0015	0.0110	0.082	2.806
Women	77	0.0002	0.0107	0.067	2.480
Combined	237	0.0011	0.0109	0.077	2.703
Difference (Men – Women)		0.0012		0.015	
t-statistic (H0 : diff. =0)		0.827 (P=0.40)		0.038 (P=0.96)	

The distribution of the risk aversion class across gender

The analysis of the distribution of the risk aversion scores reveals that more than half of the producers are risk averse, with positive absolute and relative risk aversion scores. More than 33% of the producers exhibit risk-loving or risk-preferring behaviour, as indicated by their negative risk aversion scores. Only very few producers are risk-neutral, with a risk aversion score equal to zero. The gender comparison shows the same tendency of the distribution of the risk aversion scores. However, the percentage of men ruling out risk-loving attitudes is lower than that of women, about 7%. As a result, 4% more of the men are risk averse with respect to output market price volatility in comparison to the women. Nevertheless, the differences remain statistically not significant even at the 10% level. Table 5.7 and the series of graphs 5.4 and 5.5 tell more about the distribution of the risk aversion scores and classes across gender.

Table 5.7: The distribution of risk aversion classes across gender.

Risk aversion class	Men		Women		Overall	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Risk averse (R_A>0)	91	57	41	53	132	56
Risk neutral (R_A= 0)	12	7	3	4	15	6
Risk loving (R_A<0)	57	36	33	43	90	38
Total	160	100	77	100	237	100

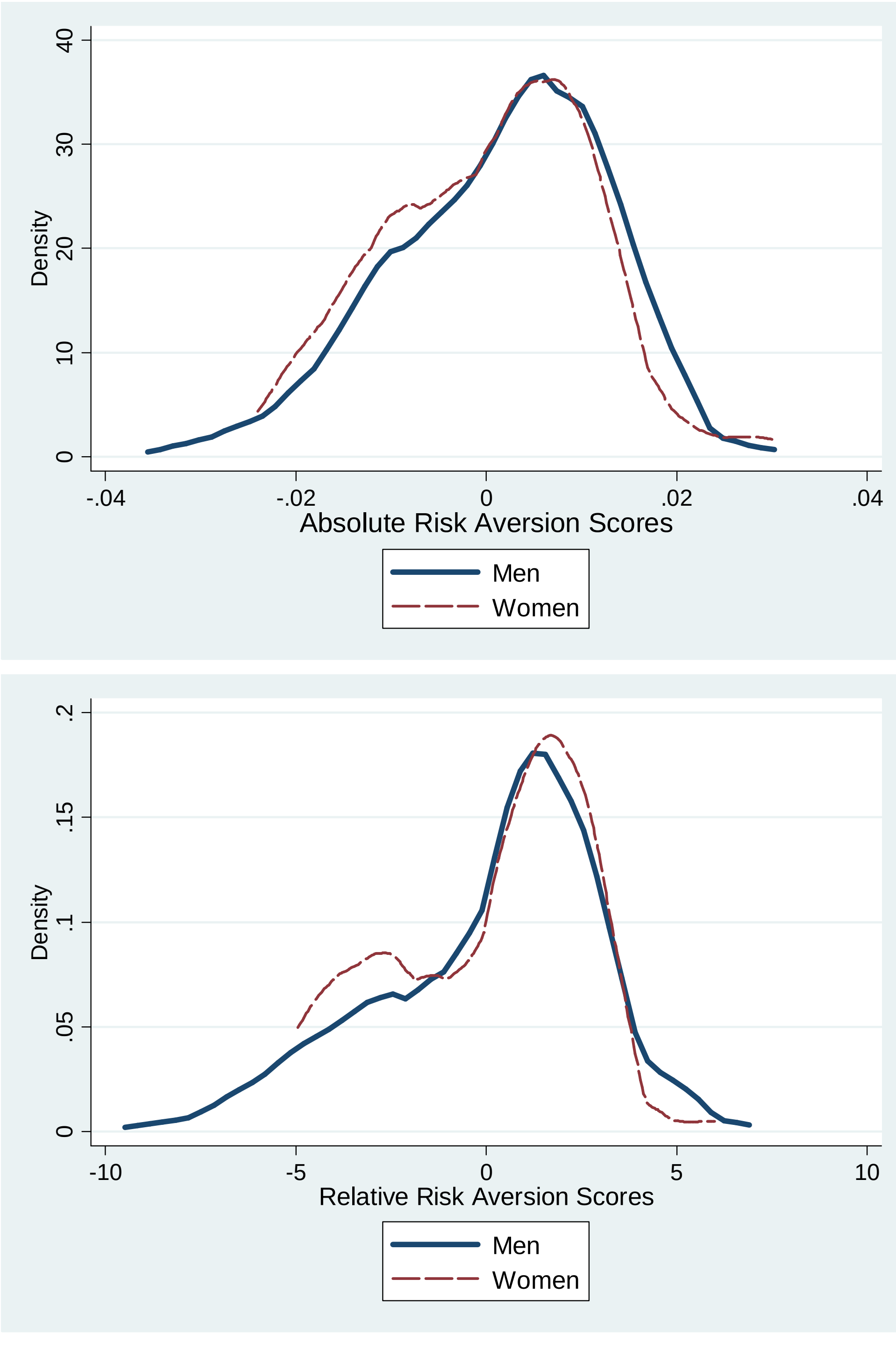


Figure 5.4: Kernel density estimation of the distribution of risk aversion scores across gender.

Figure 5.5: Histogram of the distribution of risk aversion classes across gender.

The correlation between risk attitude and risk perception

The pairwise correlation between men and women producers' risk attitude and risk perception, measured in terms of the appreciation of the annoyance about the output market price volatility, suggests a positive and significant relationship at the 5% level. This implies that when men and women producers are bothered by the price fluctuations, they are more likely to behave in a risk averse way. Moreover, the risk perception measured through the ratio maximum and minimum price predicted for next month, given the current market price, is positively correlated to men's and women's risk aversion, but the coefficient is not significant at the 10% level. Disaggregated by gender, the ratio maximum and minimum price predicted is significantly correlated to women's risk attitude at the 5% level. This suggests that the higher women's risk perception is, as reflected by the variability of the predictions or the ratio, the higher is their risk aversion toward the output market price. Contrary, risk perception measured in terms of the appreciation of predictability of the output market price is negatively correlated with risk attitude, but the coefficient is not significantly different from zero, even at the 10% level. Table 5.8 presents the pairwise comparisons.

Table 5.8: The pairwise correlation of risk perception and risk attitude across gender.

Risk perception measured in terms of	Overall		Men		Women	
	Coef	P-value	Coef	P-value	Coef	P-value
Annoying output price fluctuation (1=annoying)	0.14	0.02	0.11	0.13	0.24	0.03
Predictability of the output price (1=unpredictable)	-0.08	0.18	-0.07	0.32	-0.08	0.46
Ratio Max / Min price predicted for next month, given current price	0.07	0.26	-0.01	0.83	0.24	0.03

Risk attitude, individual and household characteristics

Table 5.9 presents the results of the regression of men's and women's absolute and relative risk attitude, controlling for all individual and household characteristics together. The results suggest that the significant determinant of risk attitude at the 5% level is only the household's land ownership. Unexpectedly, the household's land ownership has a positive effect on men's and women's risk attitude. The more a household or its men (since they are the main owners) possess land, the more risk averse men and women are. The explanation may be the land abundant households have more crops to sell, and therefore are more sensitive or careful to fluctuating prices[18]. This finding contradicts the decreasing effect of wealth on risk aversion, but is somewhat in line with findings elsewhere by Senkondo (2000) in Tanzania, and Cohen and Einav (2007) in Israel. However, as risk aversion is widely considered to be decreasing with wealth, this finding contradicts several evidences, found by Binswanger (1980) in India, Rosenzweig and Binswanger (1993) in India, Senkondo (2000) in Tanzania, Gomez-Limon *et al*. (2002) in Spain, Wik *et al*. (2004) in Zambia, Abreha (2007) in Ethiopia, and Van den Berg *et al*. (2009) in Peru.

Other variables that are supposed to capture the wealth effects, such as the household size, measured in terms of the number of members, and the size of the cropped area, are negatively related to risk attitude but are not significant at the 10% level. All the other socio-economic characteristics, such as the plot manager's gender and age, the household head's gender, separate female plots, and the location or zone, are positively related to attitude toward risk, but are not

[18] The same game was implemeted for each male and female plot manager within the household. We specified not only a "risky market A" with uncertain output prices of P_{A1} and P_{A2}, and a "risk-free market B" with a certain price of P_{Bi}, varying between P_{A1} and P_{A2} ($P_{A1} < P_{Bi} < P_{A2}$) but also a quantity to be traded. See section 5.2 for more details.

significant even at the 10% level. The variable education was also not significant, with a very low coefficient, the reason for which it was dropped from the regression (table 5.9).

Table 5.9: Risk attitude, individual and household characteristics (robust cluster in the household).

Dependent variable: risk aversion score of plot manager	Absolute risk aversion (R_A *100)		Relative risk aversion (R_R)	
	Coef.	Robust Std. Err.	Coef.	Robust Std. Err.
Plot manager's gender_01 (1=female)	-0.366	0.228	-0.927	0.600
Household head's gender (1=female)	.221	0.386	0.214	1.161
Plot manager's age (years)	0.002	0.007	0.001	0.019
Household size (members)	-0.007	0.015	-0.006	0.043
Household land endowment (ha)	0.042**	0.022	0.104*	0.062
Cropped plot size (ha)	-0.354	0.413	0.093	1.048
Separate female plots (1=yes)	.121	0.196	0.354	0.490
Location or zone_01 (1=Zone Nord)	0.003	0.155	0.076	0.402
Constant	0.010	0.398	-0.525	1.064
Observations (plot managers)	211		208	
Clusters (households)	163		160	
F (8, 162)	0.85		0.61	
R-squared	0.02		0.03	

Note: **, * significant at the 5% and 10% level, respectively.

5.5.5. The effect of risk attitude on the allocative efficiency of inputs

As risk behaviour determines decision making, it may have an effect on producers' economic performance and particularly on their efficiency. For this reason, the hypothesis tested is whether more risk averse plot managers and allocate their inputs (seed, fertilizers and pesticides) less efficiently. To empirically test this hypothesis, gender-specific allocative inefficiency models are used for risk averse plot managers (R_A>0 or R_R>0).

As expected and in line with the theoretical model, the regression of the allocative inefficiency of inputs shows a positive relationship with plot manager's absolute risk aversion score for both the men and women who are behaving as risk averse producers. This suggests that without controlling for any characteristic, the allocative inefficiency increases with risk aversion. The more men and women plot managers are risk averse, the more they are likely to use fewer inputs than the optimum amount given the output market price risk. The analysis of the coefficients of the regression indicates that a one unit increase in risk aversion score times 100 (R_A*100) leads to an increase by 0.79 of men's inefficiency (P=0.08) and by 0.12 of women's inefficiency (P=0.59).

Controlling for risk perception, the plot managers' socio-economic characteristics, and location, the estimation suggests that the allocative inefficiency is positively related at the 10% level to the absolute risk aversion scores of men and women who rule out risk averse behaviour (table 5.10). The effects of risk averse behaviour on the allocative efficiency are statistically significant at the 1% level for men and the 10% level for women. This means that the more men's and women's risk aversion scores are closer to zero (risk-neutral), the more they are allocatively efficient. This behaviour corresponds to the theoretical model's predictions, since the risk-neutral, allocatively efficient producers are the benchmark.

Moreover, for men, risk perception measured in terms of the appreciation of the predictability of the output market price is positively related to the allocative inefficiency. Perceiving the output market price as unpredictable and accordingly as a real risk, increases the allocative inefficiency, although the effect is not significant at the 10% level. For women, the effect of risk perception could not be measured because they have an almost similar perception.

In addition, the results indicate that among the variables controlled, those having a significant effect (10% level) on the inefficiency are age and location for risk averse men. The allocative inefficiency increases with the age of male plot managers. Accordingly, the younger risk averse men are more allocatively efficient than the elder men. The negative and significant correlation of the dummy variable centre zone indicates that male producers located in the centre zone of Niayes allocate their inputs more efficiently compared to those in the north and the south. Producers located in the centre and south of the Niayes Zone have more marketing opportunity because they are surrounded by big daily and weekly rural horticultural markets and are also closer to Dakar. These marketing advantages may impact positively on their output in value and, consequently, on their marginal value product and their efficiency.

Other variables such as household education, the number of wives, and access to credit have the expected negative sign for risk averse men, but do not significantly influence their allocative inefficiency. Similarly, the interaction risk aversion score and women's status as first, second or third wife is negatively related to inefficiency, but the effect is not significant at the 10% level (table 5.10).

On the other hand, considering relative risk aversion scores, the estimates present some similarity in terms of sign and magnitude (table 5.10).

Table 5.10: Estimation results of the effects of the producer's risk attitude on the allocative inefficiency of inputs over gender.

Allocative inefficiency	Absolute risk averse (R_A *100>0)		Relative risk averse (R_R >0)	
	Men	Women	Men	Women
Risk aversion score of plot manager (R_A *100 or R_R)	1.22*** (0.49)	0.28* (0.15)	0.55 (0.24)	2.36 (2.69)
Predictability of output price_01 (1=unpredictable)	0.56 (0.60)		0.53 (0.62)	
Age of plot manager (years)	0.04* (0.02)		0.04* (0.02)	
Household head's education_01 (1=educated)	-0.22 (0.75)		-0.20 (0.78)	
Number of wives	-0.44 (0.29)		-0.42 (0.31)	
Risk aversion * Women's status_01 (1=first wife)		-0.04 (0.24)		-1.22 (1.34)
Access to credit_01 (1=access)	-0.64 (0.51)		-0.64 (0.53)	
Plot size (ha)	0.36 (1.04)	4.79 (3.26)	0.25 (1.08)	-0.20 (8.97)
Centre zone_01 (1=Center)	-1.06* (0.58)		-0.51 (0.61)	
South zone_01 (1=South)		0.27 (0.46)		-0.69 (1.63)
Constant	-1.45 (1.37)	-0.29 (0.24)	-0.60 (1.43)	-1.89 (2.40)
Observations (plot managers) F R-squared	85 1.88* 0.16	24 1.02 0.07	85 1.03 0.09	22 0.53 0.11

Note: ***, **, * significant respectively at the 1%, 5%, and 10% level; standard errors in parentheses, and for women or wives, robust standards errors adjusted for clusters in households to allow for an intra-household correlation (1-3 wives per household).

Furthermore, the husband decides on the seed variety to use for 17% of the women plot managers, while he decides on the quantity and timing of mineral fertilizers and organic fertilizers to apply for 30% and 11% of the women plot managers, respectively. Accordingly, the decision maker, whether it is the woman plot manager herself or her husband and his/her risk attitude, may have an effect on women's allocative inefficiency in the choice of inputs. To test this hypothesis, the allocative inefficiency of the inputs used by women is regressed first on the dummy variable decision maker on inputs (1=women, 0=husband), second on the risk attitude of the decision maker, controlling for women's risk aversion scores or not. The dummy variable decision maker turns out not significant at the 10% level, either controlling for women's risk attitude or not. The same result holds for the decision maker's risk attitude. Accordingly, this finding shows that even if for some women, the husband decides on the use of inputs, it is likely that women always have their say and their risk attitude significantly affects their allocative inefficiency, as shown in table 5.10.

5.5.6. The effects of risk attitude on the choice of labour contract

The two groups' mean comparison test, with unequal variance done, showed that men and women producers hiring labour under a sharecropping contract exhibited a higher absolute risk aversion score than those hiring labour based on a wage contract or using household labour. Considering the relative risk aversion scores, producers hiring labour under a sharecropping contract are on average risk averse, while those using wage labour or household labour are risk-takers, as shown by their negative average scores. As can be read from table 5.11, the differences are significant at the 5% level, for the absolute risk aversion scores.

Table 5.11: Risk aversion scores across labour contract choice

Labour	Obs.	Absolute risk aversion scores (R_A)		Relative risk aversion scores (R_R)	
		Mean	Std. Dev	Mean	Std. Dev
Sharecropping labour	75	0.0030	0.0098	0.407	2.21
Household and wage labour	162	0.0002	0.0113	-0.080	2.90
Combined	237	0.0011	0.0109	0.077	2.63
Difference		-0.0028		-0.487	
t-statistic (H0 : difference = 0)		-1.946**		-1.27	

Note: ** significant at the 5% level.

Moreover, the seemingly unrelated bivariate probit model estimated indicates, as expected, a positive and significant relationship (at the 10% level) between the choice of a sharecropping labour contract and the producer's risk aversion score. Meanwhile, the choice of labour based on a wage contract is negatively related to the producer's risk aversion score, although the effect is significant only at the 14% level. As expected, more risk averse producers are likely to choose a sharecropping labour contract rather than a wage labour contract. The likelihood ratio test of Rho is significant at the 1% level, indicating an efficiency gain estimating a bivariate probit rather than two single probit models (table 5.12).

Table 5.12: The choice of labour contract and the producer's risk attitude: a seemingly unrelated bivariate probit estimation.

Dependent variables	Explanatory variables	Absolute risk (R_A*100)		Relative risk (R_R)	
		Coef.	Std Err	Coef.	Std Err
Sharecropping contract_01 (1=sharecropping)	Risk aversion score Constant	0.147* -0.500***	0.079 0.086	0.056* -0.473***	0.029 0.085
Wage contract_01 (1=wage)	Risk aversion score Constant	-0.154 -1.379***	0.106 0.118	-0.046 -1.400***	0.034 0.120
	Rho LR Chi2(1)	-0.509 8.540***	0.156	-0.511 8.635***	0.156

Note: ***, * significant at the 1% and 5% level, respectively.

Furthermore, controlling for individual and household socio-economic and institutional characteristics as well as for location, the estimation of the binary choice model again suggests a positive and significant effect at the 5% level, of the producer's risk attitude on the choice of a sharecropping contract (table 5.13). We can conclude from the analysis of the marginal effect that an increase by one unit of the producer's risk aversion score times 100 (R_A*100) raises by 0.05 the probability of opting for a sharecropping contract rather than a wage labour contract or household labour. This means that more risk averse producers would prefer to hire labour based on a sharecropping contract. As mentioned by several authors (Stiglitz, 1989; Pender and Fafchamps, 2000; Braido, 2008), one of the main advantages of sharecropping was associated with its risk-sharing between the producer/landowner and the tenant. This finding may be important for three reasons. First, the object of risk is the output market price, which is subject to high fluctuations over time and even from one day to another. Second, the crops studied are horticultural crops (mainly vegetables) and are easily perishable. Third, producers lack the necessary means of storage and conservation, and have only very limited access to the foreign market to export their production.

Besides, the probit estimation with robust clusters in households indicates that, in addition to the producer's risk attitude, some other variables may significantly affect the choice of a sharecropping contract (table 5.13). Being a female producer decreases the probability of hiring labour under a sharecropping contract by 0.45. Thus, women are more likely to rely on household labour, mainly because of the small size of their plots and their limited access to improved irrigation equipment. Obviously, sharecroppers require a certain level of plot size (1000 m^2 on average) and irrigation equipment. Household size in terms of the number of members has a negative and significant effect at the 10% level on the probability of going for sharecropping. This can be explained by the fact that the greater the household size is, the greater is the labour availability and the less is the need to take recourse to sharecropping labour.

The number of wives of the household head is positively and significantly related at the 1% level to the choice of sharecropping contract. Having an additional wife increases the probability of the male producer hiring labour based on a sharecropping contract by 0.13. An explanation may be the need to crop more in order to satisfy the needs of additional wives and children, which require more labour and, consequently, the recourse to sharecroppers. Access to credit also has a positive and significant effect on the probability of choosing a sharecropping contract. The reason is that sharecroppers require from producers/landowners to have at their disposal, in the right quantity and on time, all the inputs necessary for production. Consequently, households who have better access to credit may be able to afford more hired labour based on a sharecropping contract, compared to others.

Access to extension services significantly decreases at the 1% level the probability that the producer will opt for a sharecropping contract. The location has a positive and significant effect on the probability of choosing sharecropping. Especially being located in the north zone increases the probability of hiring labour based on a sharecropping contract by 0.30. Producers located in the northern zone of Niayes are more likely to choose a sharecropping contract compared to those in the centre and the south, who have a relatively larger plot size and are better equipped. For these reasons, they more often prefer to hire labour based on a wage contract in case the available household labour is not sufficient.

Other variables like the producer's age, the household head's status, the education, the plot size, women's annual income, and the centre zone dummy were initially included in the model, but were removed later on because they are not significant even at the 10% level. Controlling for the relative risk aversion score rather than the absolute risk aversion score, the marginal effect of risk becomes equal to 0.02, while the marginal effects of all the other explanatory variables remain the same.

Table 5.13: Probit estimation results and marginal effects of producer risk attitude on choice of sharecropping contract (robust cluster in household)

Sharecropping_01	Coefficient	Robust Std. Err.	Marginal Effect
Risk aversion score of plot manager (R_A *100)	0.178	0.089**	0.051**
Producer's gender_01 (female=1)	-2.387	0.450***	-0.447***
Wives	0.461	0.133***	0.133***
Household size (members)	-0.048	0.027*	-0.013*
Credit_01 (1=access)	0.547	0.226***	0.159***
Extension_01 (1=access)	-0.804	0.311***	-0.178***
Zone Nord_01 (1=Nord)	0.996	0.266***	0.305***
Constant	-1.024	0.290***	
Observations (plot managers) Clusters (households) Wald chi2(7) Pseudo R2 Log Pseudo Likelihood	218 159 44.35*** 0.28 -96.86		

Note: ***, **,* significant at the 1%, 5% and 10% level, respectively.

5.6. Conclusion and policy implications

Agricultural production is typically a risky business. Farm households have to tackle several risks. For this reason, farm households' risk attitude is an important issue connected with their decision-making and may greatly affect their economic performance. Particularly in Senegal, for horticultural households, the output market price is one of the foremost risks, due to its high volatility. During the production, a household can never be completely certain at which price they will be able to sell their produce later on, after harvesting. Moreover, within the same household, the husband and wives may behave differently towards risk. This research has provided theoretical and empirical evidence of the measures and effects of risk attitude across gender on economic performance and on the choice of inputs. More precisely, based on an experimental game implemented in Senegal's Niayes Zone, this chapter has investigated the gender dimension of risk attitude and the causal relationship between risk attitude, the allocative inefficiency of the choice of inputs, and the decisions made regarding the choice of labour contract, controlling for other exogenous characteristics.

The results showed that, on average, men and women producers are absolutely risk averse towards the output market price. In addition, men are as risk averse as women are. The reason for this is that women horticultural producers are used to going to the market to sell their own produce or to engage in small trading as an off-farm activity. Consequently, women know a lot about how the market operates, at least as much as men know. This finding is in line with some other findings elsewhere, but challenges the common finding that women are more risk averse than men are. Finally, we can conclude that, depending on the type of risk measured, the knowledge or the experience about the risk and the cultural, social, and economic context, women may behave as risk aversely as men do, or even less.

Controlling for individual and household characteristics together showed that the only significant determinant at the 5% level of men's and women's risk attitude is household land ownership. The more the household or its men (since they are the main owners) possess land, the more risk averse men and women are toward the output market price. This finding challenges the common decreasing effect of wealth on risk aversion, but is somewhat in line with findings elsewhere.

As expected and in line with the theoretical model, the empirical evidence shows that over gender and risk-behaving group, and controlling for individual socio-economic characteristics and location, the attitude towards the output market price risk significantly affects men's and women's allocative inefficiency in the use of inputs (seed, fertilizers and pesticides). Specifically, the results suggest that the more risk averse men and women plot managers are, the more they allocate their inputs inefficiently. This means that the more men and women producers are risk averse, the more they are likely to use a suboptimum amount of inputs, given the output market price risk. A one unit increase in the risk aversion score times 100 of men and women with risk averse behaviour, leads to an increase by 1.22 and 0.28 of their allocative inefficiency, respectively, controlling for location and individual characteristics. In addition, the estimation shows that other variables having a significant effect on the allocative inefficiency of inputs are age and location. The allocative inefficiency increases with the age. Producing in the centre zone of Niayes, significantly decreases the allocative inefficiency; this may be due to more marketing opportunities.

Furthermore, the estimation of the binary choice model suggested a positive and significant effect at the 5% level of the producer's risk attitude on the choice of a sharecropping contract. Thus, the empirical evidence confirms the theoretical model that the more producers are risk averse, the more they would prefer to hire labour based on a sharecropping contract rather than a wage contract. From the analysis of the marginal effect, it can be concluded that an increase by one unit of the producer's risk aversion score times 100 raises by 0.05 the probability of opting for a sharecropping contract instead of a wage labour contract or household labour, controlling for location, individual and household socio-economic characteristics, and institutional characteristics. All the other variables controlled, like the plot manager's gender, household size, the number of wives, the household's annual income, location, and access to credit and extension, also significantly affect the choice of a sharecropping contract. While the probability of opting for sharecropping decreases with being a female plot manager, the household's size and its access to extension, it rises with the household's annual income, location, access to credit, and the number of wives.

The findings resulted in a number of recommendations to policy decision makers, in terms of strategies that may help to dampen down men and women producers' risk aversion towards the output market price and its repercussions on their efficiency. Such strategies should aim at reducing and tackling, or coping with, the output market price risk.

Furthermore we can conclude, basing ourselves indirectly on the research outcomes and directly on the field observations, that to cope better with the output market price risk, men and women producers need to have access to adequate means of storage and conservation of horticultural products, which by nature are easily perishable. Being able to conserve their production may allow producers to delay and to spread the selling over time, in order to avoid an oversaturation of the market and its repercussions. Training in postharvest technologies is an important prerequisite to increase the ability of producers to preserve the quality and the freshness of the produce for a longer time. Research institutes and extension services have a lot to do to attain an efficient transference of postharvest technologies to producers. However, these measures may only have a significant effect if they are coupled with access to a suitable system of microcredit for personal consumption, which will allow producers to be not constrained to sell off their production.

At the community level, horticultural producers should be better organized in order to have more market power in relation to the middlemen traders, who used to impose their price. Some efforts should be oriented toward the reinforcement of the organization of horticultural producers. Making horticultural production zones more reachable through an improvement of the roads may facilitate producers' access to diverse markets. An efficient and daily updated system of information about the market price, accessible to producers and based on the new technology of communication (the mobile phone, for instance) may be helpful to deal with the market price risk. A smart policy of market protection may produce significant effects on the regulation of the market for some products, like onion, during the period of overproduction, while preserving the consumers' interests, too. This set of strategies needs some empirical evidence and may be a good agenda for future research.

Chapter 6.

Conclusions and Discussion

6.1. Introduction

In agriculture-based economies like Sub-Saharan African countries where the majority of the population derive their food and livelihoods from agriculture, getting agriculture to move forward should be high on the development agenda. Moreover, the drastic changes in 2007-09 in the world food situation which affects Africa more than any other region call for policy decision makers to pay much more attention to the supply side of agriculture both at the local and the global level in order to achieve a sustainable productivity growth (de Janvry, 2009). This attention should be paid to food crops as well as to market-oriented or cash crops. In fact, cash crops combined with high-added value products like horticultural crops offer opportunities to boost agricultural growth in developing countries like Senegal where horticulture is a key element of the agricultural sector. Accordingly, more than ever, there is a need to examine the economic performance of the agricultural producers, and particularly the efficiency of the use of scarce resources in order to confront the challenges ahead. However, the key role of women in the agricultural sector in many parts of the world, and particularly in agriculture-based countries like African countries, calls for more gender-sensitive approaches and policies allowing for gender identity. Together, all these reasons widely justify the relevance of this research thesis which aims at investigating the economic performance of horticultural households in Senegal by using efficiency as a main indicator and adopting a gender perspective.

Efficiency is assessed in a specific social, cultural, economic, and institutional context, in which polygamy occurs and husband and wives usually manage their plots separately. Also, next to household labour, the labour market offers possibilities to hire labour under two common forms of contract, based on either sharecropping or wage. In addition, with the high volatility of the prices of horticultural products, the market risk is challenging. Therefore, from this context emerge four main research questions we have addressed in this thesis, related to (i) the efficiency of the allocation of household resources over men and women, (ii) the efficiency of contracts with hired workers, either as wage labourers or as sharecroppers, for household profit optimization, (iii) risk behaviour across gender, and (iv) its effects on the economic performance and the choice of labour contracts. Three chapters (Chapters 3, 4, and 5) have provided theoretical and empirical evidence on these research questions, preceded by two chapters (Chapters 1 and 2) in which we have expounded the purpose and background of this research.

This concluding chapter will present the synthesis and discuss the main findings from the different chapters. Overall, this chapter will answer the fifth research question and come up with policy recommendations, by examining the suitable strategies leading to an improvement of the economic performance of horticultural households. The remainder of this concluding chapter will proceed as follows. The next section 6.2 will summarize and discuss the main findings and their scientific relevance with respect to the general body of the literature on efficiency, gender, land or labour tenancy, and risk behaviour. Section 6.3 will deal with the policy implications and relevance of the findings. Finally, section 6.4 will present the main limitations of the study and puts forward the outlook for future or further research.

6.2. Summary and discussion of the main findings

The efficiency of the allocation of resources over husband and wives

Research question 1: is the household's allocation of resources over men and women or husband and wives efficient?

The objective of Chapter 3 was to address this first research question by examining the efficiency of the distribution of resources within horticultural households in Senegal. To do so, we estimated and compared unitary or pooled models with gender as explanatory variable and gender-specific stochastic frontier production functions. From these models, we derived the technical and allocative efficiency, the inefficiency component, and its relationship with other individual and household socio-economic characteristics.

Preliminary results of the gender comparison of inputs and output show that women's plots are more input-intensive and yield 17% more in terms of output in value per hectare than men's plots do. However, with an average of 460 m^2, women's plots are 4.7 times smaller than men's plots are. The likelihood ratio test shows that all the estimates of the unitary and gender-specific models are significantly different at the 10% level. Consequently, men's stochastic frontier production function differs significantly from that of women, indicating some difference in the technology used.

Moreover, the examination of the coefficients of the stochastic frontier production functions corresponding to the output elasticity shows some economically important differences. This supports the suitability of using gender-specific models rather than the unitary model, when the aim is to better capture the gender differential of performance. For instance, according to gender-specific models, an increase by one percent of inputs leads to an increase by 0.31% of output in value per hectare on men's plots and by 0.16% on women's plots. Capital irrigation equipment provides another example, with an output elasticity of 13% on women's plots and -11% on men's plots. Including a gender dummy variable as explanatory variable in the unitary model, as is usually done, is not enough because the gender variable comes out not significant. In order to capture such a gender difference, the alternative of the gender-specific models should rather be to interact each of the explanatory variables with the gender dummy and add the interaction variables to the unitary model. The test of parameters confirmed, too, that the variables interacted with gender jointly are significantly different from zero at the 1% level.

Both the unitary model and the gender-specific models predictions show that women plot managers are as technically efficient as men plot managers are. Moreover, the gender-specific models show that the determinants of technical inefficiency effects present some similarities as well as some differences between male and female plot managers. For both men and women, inefficiency effects are significantly related to the location or zone, and the age and number of men working on the plot. However, contrary to the men, the women's inefficiency effects increase with age and decrease with male labour. The elder male plot managers exhibit a low inefficiency compared to the younger ones because they have more experience in horticultural production and, consequently, more knowledge to choose the appropriate varieties, and more skill to combine the inputs for a better yield. Moreover, their accumulated experience improves their managerial capacity to mobilize the household labour, to schedule and to carry out in a well-timed way the cropping operations that affect the yields. Contrary to the men, the younger women are more technically efficient than the elder ones. The explanation may be that the younger women have less children to care for, are stronger, and have to do demanding tasks. Thus, younger women have more time to devote to their production activities and can manage better to carry out their cropping operations timely, with a positive effect on their yield.

Contrary to men's plots, the number of male household members working on women's plots contributes to lessen women's inefficiency effects. Actually, in terms of timing and dosage of inputs application, men are more experienced and are mostly the advisers or decision makers on women's plots. In addition, men's inefficiency effects decrease when their wives manage their plots separately, while women inefficiency effects augment with being head of the household and diminish with the share of women's off-farm income in their total income. Altogether, such determinants of inefficiency over gender should be considered in the formulation of strategies aimed at the improvement of men's and women's technical efficiency. For instance, particular attention should be paid to female household heads and young male household heads for any intervention providing technical advice.

Furthermore, based on gender-specific models, the value of the marginal product of land, inputs, labour, and irrigation equipment differs significantly from men's to women' plots within a household. Consequently, in addition to the gender difference in the technology used, the gender distribution of the resources within household has implications for the allocative efficiency. The value of the marginal product of land is higher on women's plots than it is on men's plots. Actually, an increase of land cropped by one hundred square meters, holding all other inputs constant, will rise by fcfa 21,000 and 63,000 the output on men's and women's plots, respectively. The value of the marginal product of inputs is 72% higher on men's plots than it is on women's plots. Likewise, the values of the marginal products of household labour and hired wage labour are, respectively, 5 and 4 times higher on men's plots than they are on women's plots. However, the value of the marginal product of irrigation equipment is higher on women's plots than it is on men's plots. Accordingly, while within a household, land and irrigation equipment are better valued on women's plots, labour and others inputs are better valued on men's plots. Moreover, beyond an intra-household context, neither male nor female plot managers achieved absolute allocative efficiency for any inputs, showing their lack of ability to combine inputs profitably in such a way as to equalize the value of their marginal products to their unit prices.

From these findings, we conclude that, optimality or allocative efficiency from a household perspective that corresponds to an equality of the value of the marginal product of the inputs between men's and women's plots within the household, is far from being achieved. In the allocation of land, inputs, labour, and capital irrigation equipment, for instance, some improvements can be made by shifting labour and inputs from women's plots to men's plots, and shifting land and capital equipment from men's plots to women's plots. However, given that both men and women are allocatively inefficient for land, labour, equipment, and other inputs, rather than shifting, it may be better to scale up these inputs to reduce the inefficiency. Given that households are cropping on average 59% of their available land, there are some possibilities or potentialities to widen the cropped area, but this is conditional on a better access to labour-saving irrigation equipment.

Altogether, these findings confirm the findings by Udry (1996) and cast doubt on many household models implicitly assuming efficiency regarding the allocation of resources within the household. However, contrary to Udry (1996) who found that women's plots yield less than men's plots because of lower levels of input use on women's plots, we found that women's plots are more input-intensive and yield 17% more in terms of output in value per hectare than men's plots do. In addition, the value of the marginal product of land is higher on women's plots than it is on men's plots within the same household, suggesting a reallocation of land in favour of women that is contrary to Udry's findings. In terms of efficiency, men are as efficient as women are, but neither men nor women are fully efficient either technically or allocatively. This finding is consistent with findings elsewhere in Africa, as has recently been shown by Alena *et al.* (2008) in Kenya and, before that, by Adesina and Djato (1996) in Côte d'Ivoire.

The efficiency of labour contract choice for household profit optimization

Research question 2: are the contracts with hired workers, hired either as wage labourers or as sharecroppers, efficient for household profit optimization, also after accounting for the irrigation equipment of the farm?

We have addressed this second research question in Chapter 4. In agriculture, the coexistence of different forms of land tenancy or labour contract have been explained so far by theories related to Marshallian inefficiency, incentives, risk sharing, and transaction costs, including supervision costs. These theories and the empirical evidence have greatly contributed to explain the reasons behind land tenancy or labour contract choice. This study goes a step further, by focusing especially on production technologies at the plot level. This study provides theoretical and empirical evidence by designing and testing a model based on household profit optimization, (i) to compare the optimum profit derived from plots under household labour, a sharecropping labour contract and a wage labour contract, and (ii) to test the efficiency of the labour choice made, controlling for irrigation equipment used on the plot. The model does not account for risk behaviour, but focuses mainly on the supervision costs of labour under a wage contract and on opportunity wage ratios of sharecropper and wage worker, of sharecropper and landlord, and of wage worker and landlord. In order to test the efficiency of the labour contract choice, for each plot, simulations were made to see if another labour contract than the one presently applied would yield a higher profit to the household.

Considering that the average rate of the supervision of wage labour applied by a household is estimated at 24%, it comes out that, on average, on plots without motor pumps, a sharecropping contract provides a higher optimum profit to a household than a wage contract does. However, on plots irrigated with a motor pump, even if the wage paid by a household is two times greater than the opportunity wage of a sharecropper, corresponding to a supervision rate of 100%, this household would still prefer to hire labour based on a wage contract rather than a sharecropping contract to maximize its profit. All in all, on plots equipped with a motor pump, hiring labour based on a wage contract is always more profitable for the household than hiring labour based on a sharecropping contract. Many plots without a motor pump under a wage labour contract (66%) should be under a sharecropping contract if they were to achieve household profit optimization. Also, 18% of the plots with a motor pump under a sharecropping contract should be under a wage labour contract if they were to achieve household profit optimization. Altogether, plot managers made the efficient or right labour choice, which maximizes their profit for 73% of the plots under sharecropping as well as wage labour contracts.

The test of efficiency of input use indicated that, on average, controlling for crop, fertilizer is used inefficiently both on plots without a motor pump and on plots irrigated with a motor pump, although the latter exhibit generally higher efficiency scores. The inefficiency may persist over time mainly because of institutional constraints such as the limited access to credit, the expensiveness of the fertilizers which are rarely subsidized, and the lack of technical advice from agricultural research and extension services for an adequate dosage and timing of application of fertilizers. The persistence of the inefficiency casts doubt on the quality of the fertilizers used. In addition, controlling for crop and labour, the findings suggest that the input is used as inefficiently on plots under household labour as on plots under a sharecropping contract or a wage labour contract. Consequently, this empirical evidence challenges the Marshallian common knowledge connecting sharecropping to inefficiency and corroborates recent findings elsewhere.

To conclude, these findings help us to better understand the reasons behind the existence and the perpetuation of sharecropping over time and over developing countries, like Senegal. While on plots without a motor pump, a sharecropping contract is the efficient labour contract choice, leading to a higher optimum profit for the household, on plots irrigated with a motor pump, a wage contract is the best labour contract choice. Consequently, this finding indicates that, with the use of improved labour-saving equipment or technologies, or more broadly with the modernization of production, the future of the sharecropping contract is threatened, in favour of household labour and the wage labour contract. Unless the sharing rules commonly applied, based on a 50-50 distribution of the profit, change to a greater share for the landowner, households will be less and less willing to hire labour under a sharecropping contract with the growing use of labour-saving technologies.

Measures and effects of risk attitudes across gender

Research questions 3 and 4: do risk preferences differ between husband and wives, and between male and female heads of the household? If so, how are they related to individual characteristics, and what are the effects on their performance and choice of labour contracts?

In Chapter 5, we have investigated these research questions theoretically and empirically. Agricultural production is typically a risky business. When producing, farm households have to tackle several risks and for this reason, the way they behave towards risk may be connected with their decision-making and may affect their economic performance. Particularly in Senegal, for horticultural households, the output market price is one of the foremost risks, because of its high volatility. Chapter 5 provided theoretical and empirical evidence of the measures and effects of risk attitude on economic performance and on the choice of inputs. We examined these issues across gender. More precisely, based on an experimental game implemented in Senegal, Chapter

5 scrutinized the gender dimension of risk attitude and the causal relationship between risk attitude, the allocative inefficiency of the choice of inputs, and the decisions made regarding the choice of labour contract, controlling for other exogenous characteristics.

The results show that, on average, both men and women producers display an absolute risk aversion towards the output market price. In addition, women are as risk-averse as men are. The reason is that female horticultural producers used to go to the market, selling their own produce or engaging in small trading as off-farm activity. Consequently, women know as much about how markets operate as men do, or know even more in comparison to men who sell their produce at the field gate. This finding is in line with some other findings elsewhere, but challenges the common finding that women are more risk-averse than men are. It can be concluded that, depending on the type of risk measured, the knowledge or the experience about the risk, and the cultural, social and economic context, women may behave as risk-averse as men do or are even less averse to taking risks.

Controlling for individual and household characteristics together, the significant determinant of men's and women's risk attitude mainly is household land ownership. The more a household or men (since they are the main owners) possess land, the more men and women are risk-averse toward the output market price. This finding challenges the common decreasing effect of wealth on risk aversion but is consistent with some findings elsewhere.

As expected and in harmony with the theoretical model, the empirical evidence shows that over risk-behaving group and gender, the attitude towards the output market price significantly affects men's and women's allocative inefficiency in the use of inputs. The finding suggests that the more men and women plot managers are risk-averse, the more they allocate their inputs inefficiently, because they are likely to use a suboptimum amount of inputs given the output market price risk. Moreover, the estimation shows that other variables having a significant effect on allocative inefficiency are age, and location. Actually, allocative inefficiency increases with age. In addition, producing in the centre zone of Niayes significantly reduces the allocative inefficiency. This location effect may be due to more marketing opportunity, caused by the proximity to Dakar, the capital city, and the several big rural horticultural markets surrounding the south and the centre of the Niayes Zone, compared to the north zone of Niayes.

Furthermore, the empirical evidence confirms the theoretical model's assumption that the more producers are risk-averse, the more they would prefer to hire labour based on a sharecropping contract rather than a wage contract. The other variables controlled for, like the plot manager's gender, the household size, and the access to extension, both significantly and negatively affect the choice of sharecropping contract, while the number of wives, the location (the north zone of Niayes), and access to credit both significantly and positively affect the choice of sharecropping contract. Innovatively, this finding reinforces the theory about sharecropping and risk and brings new empirical evidence on the reasons behind the choice for sharecropping and therefore complements Chapter 4.

We can conclude from all these findings that men are as risk-averse as women are toward the output market price. Their risk attitude prevents them from achieving allocative efficiency in the use of inputs and so reduces their economic performance. Given that men's and women's risk aversion behaviour explains their inefficiency, the conventional measure of allocative efficiency, which implicitly assumes certainty, is not appropriate any more under risky environmental circumstances unless there is a risk insurance market to cover the risk. Otherwise, the evidence implies that a producer's risk behaviour should be integrated directly in the production function used to derive allocative efficiency.

Moreover, the findings suggest that the decision-making on labour choice is driven by the producer's risk attitude. To be more risk-averse leads to a choice for a sharecropping contract rather than a wage contract. This may have implications for producer's economic performance, if sharecropping is not the efficient choice with an eye to providing a higher optimum profit. All in all, the findings illustrate that the producers' risk behaviour is an important issue, which affects their choice and economic performance. Although there is quite extensive theoretical literature on the output price risk, the empirical evidence is rather thin (Kumbahar, 2002). As pointed out by Fafchamps (2003), in the context of developing countries, theory on risk behaviour is much more advanced than empirical work is. Accordingly, this research provides a contribution to the literature about risk behaviour, both by reinforcing the theory and by providing new empirical evidence.

6.3. Policy implications

Accurate and updated information about the efficiency of male and female producers is important in the development of strategies aimed at getting agriculture to move forward by increasing productivity and improving resource use. Therefore, by providing a complete picture of men and women producers' efficiency, findings from this research may be helpful for designing appropriate agricultural development programmes that are also more gender-sensitive. Findings from Chapter 3 show that, in spite of the long experience of men and women producers within horticultural households, they are still not fully technically or allocatively efficient. These findings call for more efforts from policy decision makers to provide horticultural households with the suitable support to improve their ability to manage their productive resources more efficiently. This requires from research institutes and extension services, especially, to become more operative and to work more closely with the horticultural households. As shown by the findings, access to extension services decreases inefficiency effects.

Some cultural factors may impede the enhancement of the efficiency. Fundamentally, the position of women in the society and explicitly, the customary norms preventing rural women from land ownership, need to be addressed for a better economic performance. Despite some improvements made on the gender equity regarding land use and ownership rights, customs and a lack of information still prevent women from getting access to land. Consequently, a better awareness and information may be helpful to make more effective the legislation related to land use and ownership rights in order to attain a better gender equity.

Moreover, horticultural production is labour-intensive; in particular the irrigation operation is really time-consuming. Hence, an improvement of the technology of production through a sustainable system of credit, or a smart policy of subsidy that will allow producers to modernize their production will be useful. For instance, making accessible the use of improved irrigation equipment will lead to an increase of the scale of production, with a positive effect on efficiency. However, such a policy should be gender-sensitive, taking into account the specific problems faced by women plot managers. The findings show that land is better valued on women's plots than it is on men's plots, but neither men nor women are allocatively efficient with respect to land, implying an underuse of land. Consequently, men as well as women need to scale up their cropped land. A better access to land with a right of ownership combined with a better access to improved labour-saving irrigation equipment will be a lever to improve women's economic performance and, consequently, their well-being and the whole household's welfare, too.

The empirical evidence of Chapter 4 shows that the best labour choice, leading to higher optimum profit for a household, is a sharecropping contract on plots without a motor pump and a wage contract on plots equipped with a motor pump. These findings provide evidence that if there will be more improved irrigation equipment, then we would predict less sharecropping and more wage labour, but the overall employment effects are arguably negative. Moreover, the improvement of the irrigation equipment, not only will make the production system less labour-intensive, but also will enable large-scale production. This is a tradeoff, from a short-term rural development perspective.

The findings of Chapter 5 result in some recommendations to policy decision makers, in terms of strategies that may be useful to lessen men and women producers' risk aversion towards the output market price and its repercussions on their efficiency. Such strategies should reduce the output market price risk. As an indirect result of the findings and straight from the field observations, we have suggested certain strategies aimed at reducing the impact of the existing price variability or/and lowering the price variability. First of all, to better cope with the output market price risk, men and women producers need to have access to adequate means of storage and conservation of their horticultural products, which are naturally easily perishable. Being able to conserve their production may allow producers to delay and spread sales over time to avoid oversaturation of the market and its consequences. Training in postharvest technologies is a great requirement to strengthen producers' ability to keep the quality and the freshness of their horticultural production for a longer time. Research institutes and extension services have a lot to do for an efficient transfer of postharvest technologies to producers. However, these measures may have significant effects only if they are coupled with access to a suitable system of micro-credit for consumption to allow producers to be not constrained to sell off their production.

An efficient and daily updated system of information about the market price accessible to producers, based on the new communication technology (the mobile phone) may be helpful to deal with the market price risk. At the community level, to reduce price volatility, horticultural producers should be better organized to have more market power in relation to the middlemen traders, who used to impose their price. Some efforts should focus on the reinforcement of the organization of horticultural producers. Making horticultural production zones more reachable through an improvement of the roads may facilitate producers' access to diverse markets, enabling them to cope better with the output market price. The development of adapted agricultural insurance market may have positive effects on the producers' risk behaviour and on their efficiency. However, as this last set of strategies is mainly based on field observations and only indirectly derived from the findings, a further investigation may be needed to colllect more empirical evidence, which can thus be added to the future research agenda.

6.4. Main limitations and the future research agenda

From the diverse theoretical models, the empirical findings, the conclusions and policy implications emerge some limitations and a number of issues that require further investigation. Together, they form a good research agenda for the future.

The analysis carried out in Chapter 3, dealing with efficiency, is based on an approach using the stochastic frontier production function proposed by Battese and Coelli (1995). This approach allows for the cross-sectional nature of the data, with the household as the first sampling unit and the plot as the second one. In combination with the within estimation method (household fixed effects) used, which is based on maximum likelihood, it is interesting because controls for household heterogeneity and, therefore, the consistency of the estimates, do not require any assumption about the correlation between the explanatory variables and the inefficiency effects. However, the drawback is that the empirical specification of the production functions is mainly based on inputs and output in value per hectare. Consequently, the timing of the application of the inputs and the cropping operations are not accounted for, while such factors are important elements in the farming system and may have effects on efficiency. Future research on efficiency may address this issue by integrating in the stochastic frontier production function variables related to the timing of the application of each input (organic and mineral fertilizers, pesticides, biological treatment, et cetera) and of each cropping operation (irrigation, transplanting, weeding).

Also, since the evidence shows that risk attitude is related to inefficiency, a producer's risk behaviour should be integrated directly in the production function used to measure allocative efficiency. Moreover, as the outcome is sensitive to methods, using several efficiency estimation methods simultaneously (such as profit function, data envelopment analysis – DEA -, et cetera) would provide an opportunity to make a comparison of the results and to better confirm their validity and reliability. Beyond social and economic variables, other cultural factors may explain the producers' efficiency and require further investigations. More interdisciplinary research team including economists and anthropologists should explore these cultural issues. Also, a comparison of the efficiency of horticultural households and agro-business firms remains an interesting research issue in need of investigation, particularly in Senegal, where both co-exist. Such a study may help to gain a better understanding of the non-durability or short-lived character of agro-business firms, which often operate just for a short time compared to horticultural households, which manage to carry on the production and to survive permanently, despite all.

Chapter 4 provided theoretical and empirical evidence on the efficiency of the labour contract choice, controlling for the irrigation equipment used on the plot. Because of the limited number of female plot managers hiring labour in the data set, this chapter did not capture, as intended, the gender dimension of the labour contract choice for household profit optimization. This is an interesting issue to put on the future research agenda, but it does require enough gender-disaggregated data over labour contract.

As mentioned in the policy implications drawn from Chapter 5, which provided insights on risk, some of the proposed strategies to better cope with the output market price risk need more empirical underpinning. Specifically, a better organization of horticultural producers for more market power, an improvement of the roads to facilitate the producers' access to diverse markets, an efficient and daily updated system of information about the output market price accessible to the producers, a smart policy of market protection, and the producers' own coping strategies, are of particular interest for any further investigation that includes a gender perspective.

Furthermore, this research has provided some empirical evidence for the efficiency and risk behaviour of men who manage their plots separately from their wives, compared with men who manage their plots jointly with their wives. Yet, further theoretical and empirical research may help to better understand the reasons behind the land allocation by the husband to his wives within a household as well as the economic implications of this allocation. All in all, the relation between gender and economics remains an appealing research agenda.

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Summary

Women play an important role in agricultural production, particularly in Africa, by managing their own farm and by providing their labour to their husband's fields. Regardless of the predominance of a gender bias with regard to their access to resource, women constitute a vital force in the development of agriculture. Throughout the world, gender issues in the development of agriculture and women's role and contribution to agriculture continue to be a great subject of debate. Despite the wide range of literature available, the importance of agriculture to the economic development in Africa and the critical role that rural women play within this sector still constitute an attractive research agenda.

In Sub-Saharan African countries, where the majority of the population derives its food and livelihood from agriculture, a strong growth in agriculture is vital for the process of economic development. Agriculture must be the leading sector for overall growth, poverty alleviation, and the reduction of income disparities. In such a context, getting agriculture to move forward is crucial. Particularly with the drastic changes in the world food situation, which affect Africa more than any other region, much more attention should be paid to the supply side of agriculture, both for food crops and market-oriented crops. In fact, cash crops, with high added value products like horticultural products, offer opportunities to boost the agricultural growth in developing countries like Senegal, where horticulture is a key element of the agricultural sector.

Accordingly, with the recent world-wide food trouble, there is a need, more than ever, to examine the economic performance of the agricultural producers, and especially the efficiency of the use of scarce resources, to confront the challenges ahead. However, the key role of women in the agricultural sector in many parts of the world, and particularly in agriculture-based countries like African countries, calls for more gender-sensitive approaches and for policies that take people's gender identity into account. Jointly, all these reasons widely justify the relevance of this research thesis, which aims to investigate the economic performance of horticultural households in Senegal, using efficiency and profitability as main indicators and adopting a gender perspective.

Efficiency is assessed in a specific social, cultural, economic, and institutional context, in which polygamy occurs and husband and wives usually manage their plots separately. In this context, next to household labour, the labour market offers possibilities to hire labour under two common forms of contract, based on sharecropping or wage. In addition, with the high volatility of the price of horticultural products, the market risk is challenging. Therefore, from this context emerge four main research questions addressed in this thesis, related to (i) the efficiency of the allocation of household resource over men and women, (ii) the efficiency of contracts with hired workers, either as wage labourers or as sharecroppers for household profit optimization, (iii) risk behaviour across gender, and (iv) its effects on the economic performance and the choice of labour contracts. Three chapters (Chapters 3, 4 and 5) provide theoretical and empirical evidence on these research questions, preceded by two chapters (Chapters 1 and 2) setting out the purpose and background of this research.

Chapter 2 describes horticultural households from a gender standpoint, using data collected from a survey of 203 horticultural households in the Niayes Zone in Senegal. We surveyed a total of 422 horticultural plots, managed by 279 producers, of which 190 are men and 89 are women. The households grow a diversity of horticultural crops during the three main seasons. We surveyed five of the most cultivated crops, such as onion, cabbage, tomato, green bean, and potato. All these crops are destined for the national and subregional market. Only green bean is exported to European countries, mainly to France.

This descriptive chapter shows that a household homes 3 to 26 members, with an average of 10. Horticultural households derive their income essentially from horticulture, with a share of 77% of men's total annual income and 60% of women's income. Women provide 15% of the household's total annual income, estimated on average at fcfa 2.1 million. With a daily income per capita of fcfa 575, or 1.3 US dollars, horticultural household members are living slightly above the national poverty line of fcfa 497 and the new extreme poverty threshold of 1.25 US dollars in developing economies.

Household land ownership varies from 0 to 20 hectares, with a median of 3. A great gender gap occurs in particular with regard to the allocation of resource and assets, access to land, and irrigation equipment. Men are the main owners of land and irrigation equipment within the

household. In 60% of the households, women are deeply involved in horticulture, managing their own piece of land that has usually been allocated to them by their husband. However, even when they manage their own plots, women and men often work on each other's plots to carry out hard or time-consuming farming operations. With an average of 460 m^2, women's plots are 4.7 times smaller than men's plots are. However, regarding the physical conditions of the plot, no major gender discrimination is noticed. With this small plot size, the intensity of the inputs used is higher on women's plots than it is on men's plots. As a result, women's plots yield 17% more in terms of output in value per hectare and 40% more in terms of profit per hectare than men's plots do.

Horticultural production is so labour-intensive that household labour is not always sufficient and some households take recourse to hired labour. However, while some households hire labour based on a sharecropping contract (31%), others hire labour based on a wage contract (7%). The return per season to sharecropping for a sharecropper is higher on average than the seasonal wage paid by the household to a wage worker. Moreover, the most time-consuming cropping operation is irrigation, which takes 75% and 85% of the total working time of household members on men's plots and women's plots, respectively. The time-share of irrigation is on average higher on women's plots than it is on men's plots, because women do not have access to improved irrigation equipment like a motor pump. The horticultural marketing context is characterized by a high variability of the output price, which is a major risk. For the same plot and crop, the selling price of the production varies greatly from one harvesting sequence to the next one, which takes just a few days. Altogether, the descriptive chapter brings to light the research issues addressed in the following chapters.

Chapter 3 replies to the first research question by examining the efficiency of household resource allocation. It furthermore deals with the appropriateness of using gender-specific models rather than a unitary model while investigating the economic performance of male and female managers of separate plots within horticultural households. Therefore, chapter 3 contributes to the gender and economics literature, providing empirical evidence regarding intra-household resource allocation in a polygamous context in which husband and wives manage their plots separately.

Both the unitary and gender-specific stochastic frontier production functions show that women plot managers are as technically efficient as men plot managers are, but neither the men nor the women are fully technically or allocatively efficient. The determinants of technical inefficiency effects present some similarities as well as some differences between men and women plot managers. Furthermore, based on gender-specific models, the value of the marginal product of land and irrigation equipment is higher on the women's plots than it is on the men's plots, while the value of the marginal product of inputs and labour is higher on the men's plots than it is on the women's plots within the same household.

We can conclude from the findings that optimality or allocative efficiency from a household perspective is far from being achieved for all the inputs. Some improvements can be made by shifting land and irrigation equipment from men to women and by shifting inputs and labour from women to men. However, given that both men and women are allocatively inefficient in the use of inputs, rather than to shift, it is better to scale up the inputs used in order to reduce the inefficiency. Since households are cropping on average 59% of their available land, there are some possibilities or potentialities to scale up the cropped area, but this is conditional on a better access to labour-saving irrigation equipment. This suggests some policy implications, which must be more gender-sensitive, to improve both men's and women's ability to manage their productive resource more efficiently. A better access of women to land and to improved irrigation equipment will be a lever to improve women's economic performance and, consequently, both their own well-being and the whole household's welfare.

The second research question is addressed in Chapter 4. In agriculture, the coexistence of different forms of land tenancy or labour contract have so far been explained by theories related to Marshallian inefficiency, incentives, risk sharing, and transaction costs, including the costs of supervision. These theories and the empirical evidence have greatly contributed to explain the reasons behind land tenancy or labour contract choice. This study goes a step further by focusing particularly on production technologies at plot level. This study provides theoretical and empirical evidence by designing and testing a model based on household profit optimization (i) to compare the optimum profit derived from plots under household labour, a sharecropping labour contract, or a wage labour contract, and (ii) to test the efficiency of the labour choice made, controlling for the irrigation equipment used on the plot. The model does not account for risk behaviour, but focuses mainly on the supervision costs of labour under a wage contract, and on opportunity wages ratios of the sharecropper and the wage worker, of the sharecropper and the landlord, and of the wage worker and the landlord. In order to test the efficiency of the labour contract choice, for each plot, simulations were made to see if another labour contract than presently applied would yield a higher profit to the household.

As expected, the results show that the production elasticity of labour decreases when improved irrigation equipment like a motor pump is used. The technology displays an increasing return to scale on plots without a motor pump and a constant return to scale on plots irrigated with a motor pump. While on plots without a motor pump a sharecropping contract is the efficient labour contract choice, leading to a higher optimum profit for household, on plots irrigated with a motor pump, a wage contract is the best labour contract choice. Consequently, we can conclude from this finding that the use of a motor pump drives out the sharecropping contract in favour of household labour and the wage labour contract. Unless the commonly applied sharing rules, 50-50 of the profit, change with a greater share for the landowner, with the increasing use of labour-saving technologies, households will be less and less willing to hire labour under a sharecropping contract.

Chapter 5 theoretically and empirically investigates the risk issues. Agricultural production is typically a risky business. Farm households have to tackle several risks. For this reason, farm households' risk attitude is an important issue connected with decision making and greatly affects their economic performance. In Senegal, for horticultural households, the output market price is one of the foremost risks. Moreover, within the household, husband and wives may behave differently towards risk. This research provides theoretical and empirical evidence regarding the measures and effects of risk attitude on economic performance and on the choice of inputs across gender. More precisely, based on an experimental game implemented in the Senegalese Niayes Zone, this chapter investigates the gender dimension of risk attitude and the causal relationship between risk attitude, allocative inefficiency of the choice of inputs, and decisions regarding the choice of labour contract.

The results show that, on average, men and women producers display an absolute risk aversion towards the output market price, and that women are as risk averse as men. As expected, and in line with the theoretical model, the empirical evidence shows that allocative inefficiency in the use of inputs increases with risk aversion. Moreover, the empirical evidence confirms the theoretical model propounding that if producers are more risk averse, they prefer to hire labour based on a sharecropping contract rather than on a wage contract. We identify recommendations for policy decision makers in terms of strategies that may help to make men and women producers more risk-neutral towards the output market price and to dampen the repercussions of risk for efficiency.

All in all, this thesis innovatively provides theoretical and empirical evidence to add to the body of the literature of the economics of household resource allocation, with a special focus on gender, labour and risk. In addition to its scientific contribution, the thesis puts forward to decision makers a number of recommendations for a better economic performance of horticultural households with women playing a leading role, as this is in favour of household welfare. Although agricultural growth driven by horticulture is a challenge for economic growth and poverty alleviation, it is potentially achievable.

Résumé (Summary in French)

Les femmes jouent un rôle important dans la production agricole, particulièrement en Afrique, en gérant leur propre ferme et en contribuant aux travaux champêtres de leur mari. En dépit de la prédominance d'un biais lié au genre au regard de l'accès aux ressources, les femmes constituent une force vitale pour le développement de l'agriculture. Partout dans le monde, les questions de genre dans le développement de l'agriculture et ainsi que le rôle et la contribution des femmes à l'agriculture continuent d'être un grand sujet de débat. Malgré le large éventail de littérature disponible, l'importance de l'agriculture au développement économique de l'Afrique et le rôle essentiel que les femmes rurales jouent dans ce secteur constituent toujours un agenda de recherche attractif.

Dans les pays d'Afrique Sub-saharienne où la majorité de la population tire leur alimentation et leur revenu de l'agriculture, une forte croissance de l'agriculture est vitale pour le processus de développement économique. L'agriculture doit être le secteur leader pour la croissance économique, la lutte contre la pauvreté et la réduction des disparités de revenus. Dans un tel contexte, il est crucial de faire progresser l'agriculture. En particulier, avec les récents changements drastiques dans la situation alimentaire mondiale, qui affectent l'Afrique plus que toute autre région, beaucoup plus d'attention devrait être accordée à l'offre de produits agricoles, tant pour les cultures vivrières que pour les cultures orientées vers le marché. En effet, les cultures commerciales à haute valeur ajoutée comme les produits horticoles, offrent des possibilités de stimuler la croissance agricole dans les pays en développement comme le Sénégal où l'horticulture est un élément clé du secteur agricole.

Ainsi, avec la récente crise alimentaire mondiale, il est plus que jamais nécessaire, d'examiner la performance économique des producteurs agricoles et en particulier l'efficacité de l'utilisation des ressources limitées, pour affronter les défis qui nous interpellent. Cependant, le rôle essentiel des femmes dans le secteur agricole dans de nombreuses régions du monde et en particulier dans les pays à économie basée sur l'agriculture comme les pays d'Afrique, appelle à des approches plus sensibles au genre et des politiques qui tiennent compte de l'identité genre. Conjointement, toutes ces raisons justifient largement la pertinence de cette thèse de recherche qui vise à étudier la performance économique des ménages horticoles au Sénégal, en utilisant l'efficacité et la rentabilité comme indicateurs principaux et en adoptant une perspective de genre.

L'efficacité est évaluée dans un contexte social, culturel, économique et institutionnel spécifique dans lequel la polygamie est de mise et le mari et ses épouses gèrent généralement leurs parcelles séparément. Dans ce contexte aussi, à côté de la main-d'œuvre familiale, le marché du travail offre aux ménages des possibilités d'embaucher sous deux formes courantes de contrat basées sur le métayage ou le salariat. En outre, avec la grande volatilité du prix des produits horticoles, le risque de marché est un challenge. Ainsi, de ce contexte émergent quatre principales questions de recherche abordées dans cette thèse et relatives à (i) l'efficacité de l'allocation des ressources du ménage entre les hommes et les femmes, (ii) l'efficacité des contrats avec les travailleurs embauchés comme main-d'œuvre salariale ou métayère pour l'optimisation des profits du ménage, (iii) l'attitude des hommes et des femmes envers le risque du marché et (iv) ses effets sur la performance économique et le choix des contrats de travail. Trois chapitres (chapitres 3, 4 et 5) fournissent l'évidence théorique et empirique sur ces questions de recherche, précédés de deux chapitres (chapitres 1 et 2) précisant l'objet et le contexte de cette recherche.

Le chapitre 2 décrit les ménages horticoles à travers une approche genre à l'aide des données recueillies à partir d'enquêtes réalisées auprès de 203 ménages horticoles dans la zone des Niayes du Sénégal. Nous avons enquêté un total de 422 parcelles horticoles gérées par 279 producteurs dont 190 sont des hommes et 89 sont des femmes. Les ménages produisent une diversité d'espèces horticoles pendant les trois saisons principales. Les enquêtes ont porté sur les cinq espèces les plus cultivées à savoir l'oignon, le chou, la tomate, l'haricot vert et la pomme de terre. Toutes ces cultures sont destinées au marché national et sous-régional. Uniquement l'haricot vert est exporté vers les pays d'Europe et surtout en France.

Ce chapitre descriptif révèle que le ménage compte 3 à 26 membres avec une moyenne de 10. Les ménages horticoles tirent leur revenu essentiellement de l'horticulture qui constitue 77% du revenu total annuel des hommes et 60% de celui des femmes. Les femmes fournissent 15% du revenu annuel total du ménage, estimé en moyenne à 2,1 millions de fcfa. Avec un revenu quotidien par membre de 575 fcfa ou 1,3 dollars US, les membres des ménages horticoles vivent

légèrement au-dessus du seuil de pauvreté nationale estimé à 497 fcfa et le nouveau seuil de pauvreté extrême de 1,25 dollars dans les économies en développement.

La propriété foncière du ménage varie de 0 à 20 hectares, avec une médiane de 3. Il existe un grand écart de genre particulière au regard de l'allocation des ressources et des biens tels que l'accès à la terre et au matériel d'irrigation. Les hommes sont les principaux propriétaires de la terre et de l'équipement d'irrigation au sein du ménage. Dans 60 % des ménages, les femmes sont largement impliquées dans l'horticulture et gèrent leur propre lopin de terre généralement alloué par leur mari. Toutefois, même lorsqu'ils gèrent séparément leurs propres parcelles, les hommes et les femmes s'aident mutuellement pour les opérations agricoles fastidieuses ou exigeantes en temps. Avec une moyenne de 460 m2, les parcelles des femmes sont 4,7 fois plus petites que celles des hommes. Cependant, concernant les conditions physiques de la parcelle, aucune discrimination majeure fondée sur le genre n'est notée. Avec cette petite taille des parcelles, les intrants sont utilisés plus intensément dans les parcelles des femmes que dans celles des hommes. En conséquence, les parcelles des femmes rapportent 17% plus de rendement en valeur par hectare et 40% plus de profit par hectare comparées aux parcelles des hommes.

La production horticole est tellement intensive en main-d'œuvre que la main-d'œuvre du ménage n'est pas toujours suffisante et certains ménages sont obligés d'embaucher. Cependant, quand certains ménages embauchent sur la base d'un contrat de métayage (31%), d'autres embauchent sur la base d'un contrat de travail salarial (7%). Le revenu par saison du métayage pour un métayer est en moyenne plus élevé que le salaire saisonnier payé par les ménages à un ouvrier agricole salarier. En outre, l'opération culturale la plus longue ou exigeante en temps est l'irrigation qui prend les 75% et 85% de la durée totale de travail des membres du ménage sur les parcelles des hommes et sur celles des femmes, respectivement. La part de temps de l'irrigation est donc en moyenne plus élevée sur les parcelles des femmes que sur celles des hommes parce que les femmes n'ont pas accès à l'équipement d'irrigation améliorée telles que la motopompe. Le contexte de commercialisation des produits horticoles est caractérisé par une grande variabilité du prix qui est un risque majeur. Pour la même parcelle et la même culture, le prix de vente de la production varie considérablement d'une séquence de récolte à la suivante qui prend juste quelques jours. En tout, le chapitre descriptif met en lumière les problèmes de recherche abordés dans les chapitres suivants.

Chapitre 3 répond à la première question de recherche en examinant l'efficacité de l'allocation des ressources du ménage. Il traite en outre l'opportunité d'utiliser des modèles spécifiques de genre plutôt qu'un modèle unitaire pour l'analyse de la performance économique des hommes et des femmes gestionnaires de parcelles distinctes au sein des ménages horticoles. Par conséquent, le chapitre 3 contribue à la littérature sur l'économie du genre en fournissant une évidence empirique concernant l'allocation des ressources au sein du ménage dans un contexte polygame dans lequel le mari et ses épouses gèrent leurs parcelles séparément.

Tant les fonctions de production de frontière stochastique unitaire que celles spécifiques de genre montrent que femmes gestionnaires de parcelles sont aussi techniquement efficaces que les hommes. Cependant, ni les hommes, ni les femmes sont entièrement efficaces ni du point de vue technique, ni du point de vue allocation des ressources. Les déterminants des effets de l'inefficacité technique présentent certaines similitudes ainsi que certaines différences entre les hommes et les femmes gestionnaires de parcelles. En outre, les résultats des modèles spécifiques de genre montrent que la valeur du produit marginal de la terre et de l'équipement d'irrigation est plus élevée sur les parcelles des femmes que sur celles des hommes alors que la valeur du produit marginal des intrants et de la main-d'œuvre est plus élevée sur les parcelles des hommes que sur celles des femmes au sein du ménage.

Nous pouvons conclure à partir des résultats que selon une perspective ménage, l'optimalité ou l'efficacité de l'allocation des ressources est loin d'être atteinte pour tous les intrants. Certaines améliorations sont possibles en transférant de la terre et de l'équipement d'irrigation des hommes aux femmes et en transférant des intrants et de la main-d'œuvre des femmes aux hommes. Cependant, étant donné que les hommes et les femmes sont inefficaces dans l'utilisation des intrants, plutôt que de transférer, il est préférable d'améliorer l'utilisation des intrants afin de réduire l'inefficacité. Étant donné que les ménages exploitent en moyenne 59% de leurs terres disponibles, il existe certaines possibilités ou potentialités d'accroitre les superficies cultivées, mais ceci est conditionnel à un meilleur accès aux équipements d'irrigation moins intensive en main-d'œuvre. Ceci suggère certaines implications politiques, qui doivent être plus sensible au genre, pour améliorer la capacité des hommes et des femmes à gérer plus efficacement leurs ressources productives. Un meilleur accès des femmes à la terre et aux équipements améliorés

d'irrigation sera un levier pour améliorer la performance économique des femmes et par conséquent, leur propre bien-être et le bien-être de l'ensemble du ménage.

La deuxième question de recherche est traitée au Chapitre 4. Dans l'agriculture, la coexistence de différentes formes de contrat de terre ou de main-d'œuvre a été jusqu'ici expliquée par les théories relatives à l'inefficacité Marshallienne, les incitations, le partage du risque et les coûts de transaction y compris les coûts de supervision. Ces théories et les preuves empiriques ont grandement contribué à expliquer les raisons du choix de contrat de terre ou de travail. Cette étude va un peu plus loin en se concentrant particulièrement sur les technologies de production au niveau de la parcelle. Elle fournit une évidence théorique et empirique en concevant et testant un modèle basé sur l'optimisation du profit du ménage pour (i) comparer le profit optimal dérivé des parcelles sous main-d'œuvre du ménage, sous un contrat de main-d'œuvre métayère ou sous un contrat de main-d'œuvre salariale et (ii) tester l'efficacité du choix de la main-d'œuvre en tenant compte de l'équipement d'irrigation utilisée sur la parcelle. Le modèle ne tient pas compte de l'attitude au risque, mais se concentre essentiellement sur les coûts de supervision de la main-d'œuvre sous contrat salarial et sur les ratios des couts ou salaires d'opportunité du métayer et du travailleur salarier, du métayer et du ménage propriétaire de la parcelle, et du travailleur salarier et du ménage propriétaire de la parcelle. Afin de tester l'efficacité du choix du contrat de main-d'œuvre, pour chaque parcelle, des simulations ont été faites pour voir si un autre contrat que celui actuellement appliqué rapporterait au ménage plus de bénéfice.

Comme prévu, les résultats montrent que l'élasticité de la production par rapport à la main-d'œuvre diminue lorsque du matériel amélioré d'irrigation comme la motopompe est utilisé. La technologie présente une économie d'échelle croissante sur les parcelles sans une motopompe et une économie d´échelle constante sur les parcelles irriguées avec une motopompe. Sur les parcelles non équipées de motopompe le choix de contrat efficace de main-d'œuvre conduisant au plus grand profit optimal pour le ménage est le contrat basé sur le métayage, tandis que sur les parcelles irriguées avec une motopompe, le meilleur choix de contrat de main-d'œuvre est celui basé sur le salaire. Par conséquent, nous pouvons conclure de ce résultat que l'utilisation d'une motopompe pousse à abandonner les contrats de métayage en faveur de la main-d'œuvre du ménage ou du contrat de main-d'œuvre salariale. Avec l'utilisation croissante des technologies moins intensives en main-d'œuvre, les ménages seront moins disposés à embaucher sur la base

d'un contrat de métayage sauf si les règles de partage couramment appliquées, 50-50 du profit, soient modifiées avec une part plus grande pour le ménage propriétaire foncier.

Chapitre 5 étudie sur le plan théorique et empirique les questions de risque. La production agricole est généralement une entreprise risquée. Les ménages agricoles ont à s'attaquer à plusieurs risques. Pour cette raison, l’attitude au risque des ménages agricoles est une question importante liée à la prise de décision et affecte considérablement leur performance économique. Au Sénégal, pour les ménages horticoles, le prix des produits horticoles est l'un des plus grands risques. En plus, au sein d'un ménage, le mari et ses épouses peuvent se comporter différemment vis-à-vis du risque. Cette recherche apporte la preuve théorique et empirique concernant les mesures et les effets de l'attitude au risque sur la performance économique et sur le choix des intrants et selon le genre du manager de la parcelle. Plus précisément, ce chapitre basé sur un jeu expérimental mis en œuvre dans la Zone des Niayes du Sénégal, examine la dimension genre de l’attitude au risque et les liens de causalité entre l’attitude au risque, l’inefficacité du choix des intrants et les décisions concernant le choix du contrat de main-d’œuvre.

Les résultats montrent qu’en moyenne, les producteurs hommes et femmes affichent une aversion absolue au risque envers le prix du marché des produits horticoles, et que les femmes sont aussi averse au risque que les hommes. Comme prévu et en harmonie avec le modèle théorique, l’évidence empirique montre que l’inefficacité de l’allocation des intrants augmente avec l'aversion au risque. De surcroit, la preuve empirique confirme le modèle théorique soutenant que si les producteurs sont réticents au risque, ils préfèreront embaucher de la main-d’œuvre sur la base d’un contrat de métayage plutôt que sur la base d’un contrat de salaire. Nous avons identifié des recommandations pour les décideurs politiques en termes de stratégies qui peuvent aider à rendre les producteurs hommes et femmes plus neutre au risque envers le prix du marché et à réduire les répercussions du risque sur leur efficacité.

Dans l'ensemble, cette thèse apporte avec innovation de l’évidence théorique et empirique à ajouter à la littérature de l'économie de l'allocation des ressources du ménage avec un accent particulier sur le genre, la main-d’œuvre et le risque. En plus de sa contribution scientifique, la thèse propose aux décideurs un certain nombre de recommandations pour une meilleure performance économique des ménages horticoles avec les femmes jouant un rôle leader, et ceci en faveur du bien-être des ménages. Bien que la croissance agricole pilotée par l'horticulture soit un véritable défi pour la croissance économique et la lutte contre la pauvreté, il est potentiellement réalisable.

Samenvatting (Summary in Dutch)

Vrouwen spelen een belangrijke rol in de landbouwproductie, met name in Afrika, zowel door hun eigen productie van eigen grond als door hun arbeid in te zetten op de akkers van hun echtgenoot. Hoewel vrouwen aanmerkelijk minder toegang tot hulpbronnen hebben dan mannen, vormen zij een belangrijke factor in de ontwikkeling van de landbouw. In de hele wereld blijven de *gender*problematiek in de ontwikkeling van de landbouw en de rol van vrouwen en hun bijdrage aan de landbouw een belangrijk onderwerp van debat. Ondanks de vele publicaties hierover, bieden het belang van de landbouw in de economische ontwikkeling in Afrika en de essentiële rol van rurale vrouwen binnen deze sector nog steeds een aantrekkelijke onderzoeksagenda.

In sub-Sahara Afrika, waar de meerderheid van de bevolking leeft van de landbouw, is een sterke groei van de landbouw van vitaal belang voor economische ontwikkeling. Landbouw moet de leidende sector zijn voor groei en armoedebestrijding en de vermindering van de inkomensongelijkheid. In dit licht is vooruitgang van de landbouw van cruciaal belang. De recente veranderingen in de voedselsituatie in de wereld, die van meer invloed zijn op Afrika dan op welke andere regio ook, laten zien dat veel meer aandacht moet worden besteed aan de aanbodzijde van de landbouw, zowel voor de voedselgewassen als marktgewassen. Deze marktgewassen, en in het bijzonder de hoogwaardige tuinbouwgewassen bieden kansen voor groei van de landbouw in ontwikkelingslanden zoals Senegal, waar de tuinbouw een sleutelrol kan spelen.

De recente prijsstijgingen van voedsel hebben nogmaals duidelijk gemaakt dat het meer dan ooit nodig is om de economische performance van de boeren te onderzoeken en met name de doelmatigheid van het gebruik van de schaarse middelen, om zo de toekomst onder ogen te zien. De centrale rol van vrouwen in de landbouwsector in veel delen van de wereld, en met name in Afrikaanse landen, waar die sector de basis van de economie vormt, vraagt om een aanpak met gevoel voor man-vrouw verhoudingen en om beleid dat rekening houdt met verschillen tussen man en vrouw. Tezamen rechtvaardigen deze bevindingen het onderzoek van dit proefschrift naar de economische prestaties van de tuinbouwhuishoudens in Senegal, met doelmatigheid en rentabiliteit als voornaamste indicatoren en met oog voor de man-vrouw relaties.

Efficiëntie wordt beoordeeld in een zekere sociale, culturele, economische en institutionele context. Polygamie komt voor en man en vrouw(en) beheren gewoonlijk afzonderlijk hun akkers. De gebruikte arbeid wordt geleverd door het huishouden zelf maar ook via de arbeidsmarkt aangetrokken als loonarbeid of als deelpachter. Het marktrisico is groot, met prijzen voor de producten die sterk fluctueren. Dit leidt tot vier hoofdvragen van de thesis: (i) de efficiëntie van de toewijzing van de hulpbronnen van het huishouden aan mannen en vrouwen, (ii) de efficiëntie van de contracten met ingehuurde arbeiders, te weten loonarbeiders of deelpachters, (iii) het gedrag van mannen en vrouwen ten aanzien van risico's, en (iv) de gevolgen ervan voor de economische prestaties en de keuze van de arbeidscontracten. Drie hoofdstukken (3, 4 en 5) bieden theorie en de empirische uitwerking ter beantwoording van deze onderzoeksvragen. De hoofdstukken worden voorafgegaan door twee hoofdstukken (1 en 2) waarin het doel en de achtergrond van dit onderzoek worden gegeven.

Hoofdstuk 2 beschrijft tuinbouwhuishoudens met een focus op man-vrouw relaties op basis van een enquête van 203 huishoudens in de Niayes zone in Senegal. Er zijn 422 akkers in beschouwing genomen, beheerd door 279 producenten, van wie 190 mannen en 89 vrouwen. De huishoudens verbouwen een verscheidenheid aan tuinbouwgewassen tijdens de drie belangrijkste seizoenen. Wij hebben de vijf meest geteelde gewassen meegenomen, namelijk uien, kool, tomaten, sperziebonen en aardappelen. Al deze gewassen zijn bestemd voor de nationale en subregionale markt. Alleen sperziebonen worden ook geëxporteerd naar de Europese landen, vooral naar Frankrijk.

Dit beschrijvende hoofdstuk laat zien dat de huishoudens 3 tot 26 leden tellen, met een gemiddelde van 10. Tuinbouwhuishoudens halen hun inkomen voornamelijk uit de tuinbouw, met een aandeel van 77% van de totale jaarlijkse inkomen van mannen en 60% van het inkomen van vrouwen. Vrouwen zorgen voor 15% van het totale jaarinkomen van het huishouden, dat gemiddeld op fcfa 2,1 miljoen wordt geschat. Met een inkomen per hoofd per dag van fcfa 575 of 1,3 US dollar, leven tuinbouwhuishoudens iets boven de nationale armoedegrens van fcfa 497 en de nieuwe van extreme-armoede grens van 1,25 dollars in ontwikkelingslanden.

Het grondbezit van het huishouden varieert van 0 tot 20 hectare, met een mediaan van 3. Een groot verschil tussen man en vrouw treedt op bij de verdeling van toegang tot land en irrigatie-apparatuur. Binnen het huishouden zijn de mannen hoofdzakelijk de eigenaars hiervan. In 60 procent van de huishoudens zijn vrouwen zeer betrokken bij de tuinbouw. Zij voeren het beheer over hun eigen stukje grond, hun gewoonlijk toegewezen door de man. Hoewel man en vrouw hun eigen akkers beheren, werken zij toch vaak samen op elkaars akkers, vooral bij lastige of tijdrovende taken. Met een gemiddelde van 460 m^2 zijn de akkers van vrouwen 4,7 maal zo klein als die van mannen. Er zijn echter geen grote verschillen in natuurlijke gesteldheid van de akkers. Op deze kleine akkertjes worden de productiemiddelen met de hoge intensiteit gebruikt. Als gevolg hiervan zijn de opbrengsten per ha op vrouwenakkers 17 procent hoger dan op die van mannen en leveren zij 40 procent hogere winst per ha op.

Tuinbouwproductie is zo arbeidsintensief dat arbeidskracht van het huishouden niet altijd voldoende is en verscheidene huishoudens gebruiken dan ook ingehuurde arbeid. Waar sommige huishoudens arbeid aantrekken op basis van een deelpachtcontract (31 procent), trekken andere huishoudens arbeid aan op basis van arbeidscontracten (7 procent). De opbrengst per seizoen is voor een deelpachter gemiddeld hoger dan voor een seizoensarbeider in loondienst. Het meest tijdrovende werk is het water geven aan de gewassen, meestal met emmers en vanuit een put, soms met een irrigatiesysteem en een motorpomp. Het water geven kost wel 75 of 85 procent van de totale werktijd van het huishouden op resp. mannen- en vrouwenakkers. Het aandeel is gemiddeld hoger op vrouwenakkers dan op mannenakkers, omdat vrouwen geen hebben toegang tot verbeterde irrigatieapparatuur zoals een motorpomp. De markt voor tuinbouwproducten wordt gekenmerkt door een hoge variabiliteit van de prijzen, wat dus grote risico's inhoudt. Voor dezelfde akker en hetzelfde gewas kan de prijs sterk variëren tussen de ene oogst en de volgende, ook al liggen er hier maar enkele dagen tussen. Dit beschrijvende hoofdstuk brengt zodoende de onderzoeksvraagstukken aan het licht die in de volgende hoofdstukken aan de orde komen.

Hoofdstuk 3 geeft antwoord op de eerste vraag van de onderzoek door het bestuderen van de efficiëntie van de toewijzing van hulpbronnen door het huishouden. Ook wordt hier bezien of specifieke modellen voor mannen en vrouwen, in plaats van hetzelfde model voor beiden, geschikter zijn ter beschrijving van de gebruikte technologie en om te meten hoe efficiënt de aanwending van arbeid en kunstmest is op mannen- en vrouwenakkers. Zodoende draagt hoofdstuk 3 bij aan de kennis op het terrein van man-vrouw relaties en economie en verschaft het empirisch materiaal over de toewijzing binnen het (soms polygame) huishouden, waarin man en vrouw(en) hun percelen afzonderlijk beheren.

Zowel de algemene als de man/vrouwspecifieke stochastische grensproductiefuncties tonen aan dat vrouwen hun akkers even technisch-efficiënt beheren als mannen, en dat mannen noch vrouwen volledig technisch of allocatief efficiënt zijn. De determinanten van technische inefficiëntie laten overeenkomsten maar ook verschillen zien tussen mannen en vrouwen. Op basis van man/.vrouwspecifieke modellen, is de waarde van het marginale product van de grond en irrigatieapparatuur overigens op de vrouwenakkers hoger dan op de mannenakkers, terwijl de waarde van het marginale product van kunstmest en arbeid op de mannenakkers hoger is dan op die van de vrouwen binnen hetzelfde huishouden.

Uit de bevindingen kunnen wij concluderen dat optimale allocatieve efficiëntie vanuit het perspectief van het huishouden lang niet voor alle productiemiddelen wordt bereikt. Verbeteringen kunnen worden bereikt door het verschuiven van de grond en irrigatieapparatuur van mannen- naar vrouwenakkers en kunstmest en arbeid in de omgekeerde richting. Gezien het feit dat zowel mannen als vrouwen in de toewijzing van productiemiddelen inefficiënt zijn, kan een toeneming in het gebruik beter zijn dan een verschuiving. Aangezien de huishoudens gemiddeld maar 59 procent van hun beschikbare grond gebruiken, zijn er mogelijkheden om het gecultiveerde areaal uit te breiden, maar een voorwaarde is wel een betere toegang tot arbeidsbesparende irrigatieapparatuur. De beleidsaanbeveling die hieruit volgt is om meer gevoel te tonen voor man-vrouw relaties, en de efficiëntie van het beheer door zowel mannen als vrouwen te verhogen. Een betere toegang van vrouwen tot grond en verbeterde irrigatieapparatuur is een hefboom naar hogere economische prestaties van vrouwen en daarmee naar hoger eigen welzijn en dat van het hele gezin.

De tweede vraag van het onderzoek wordt behandeld in hoofdstuk 4. In de landbouw is de coëxistentie van verschillende vormen van pacht of arbeidscontracten tot nu toe verklaard vanuit theorieën over Marshalliaanse inefficiëntie, prikkels, het delen van risico en transactiekosten, inclusief de kosten van toezicht. Deze theorieën en het empirische bewijsmateriaal hebben aanzienlijk bijgedragen aan de verklaring van de keuze voor pacht en/of arbeidscontract. Dit onderzoek gaat een stapje verder door te focussen op productietechnologieën op het niveau van individuele percelen. Het onderzoek levert theoretische en empirische argumenten door het ontwerpen en testen van een model dat gebaseerd is op winstmaximalisatie van het huishouden waarmee (i) een vergelijking wordt gemaakt tussen de optimale winsten van akkers met eigen familiearbeid, met een deelpachtcontract en met een arbeidscontract tegen vast loon en (ii) de efficiëntie van de gemaakte keuzes hiertussen kan worden getoetst, rekeninghoudend met de irrigatieapparatuur die wordt gebruikt op de akker. Het model houdt geen rekening met risico, maar richt zich voornamelijk op de kosten van supervisie bij een contract tegen vast loon en op de opbrengsten bij alternatieve aanwending van arbeid van de deelpachter en familiearbeid. Om de efficiëntie van de arbeidscontractkeuze voor iedere akker te toetsen, zijn simulaties gemaakt van de winst die zou resulteren uit andere arbeidscontracten dan momenteel toegepast.

Zoals verwacht op basis van de theorie, tonen de uitkomsten aan dat de productieelasticiteit van de arbeid afneemt wanneer verbeterde irrigatieapparatuur zoals een motorpomp wordt gebruikt. De technologie kent toenemende schaalopbrengsten zonder, maar constante schaalopbrengsten met een motorpomp. Op akkers zonder motorpomp is deelpacht de efficiënte keuze, terwijl voor akkers met een motorpomp beter arbeidscontracten kunnen worden gebruikt. Het gebruik van een motorpomp verdringt dus deelpacht. Als de algemeen toegepaste regel bij deelpacht van 50-50 verdeling van de winst niet wordt aangepast ten gunste van de eigenaar, zullen, met het toenemende gebruik van arbeidsbesparende technologieën, huishoudens minder en minder bereid zijn deelpachtcontracten aan te bieden.

Hoofd stuk 5 onderzoekt theoretisch en empirisch de kwestie van risico's. Deze zijn groot in de landbouw en landbouwhuishoudens moeten verschillende risico's aanpakken. Daarom is hun houding ten aanzien van risico's een belangrijke kwestie in verband met de besluitvorming en hun economische prestaties. Voor de Senegalese tuinbouwbedrijven vormt de marktprijs een van de belangrijkste risico's. Binnen het huishouden, kunnen man en vrouw anders tegen deze risico's aankijken. Dit onderzoek biedt theorie en empirie met betrekking tot maatstaven voor houding t..a.v. risico en gevolgen ervan voor economische prestaties en de keuze van de productiemiddelen en de verschillende tussen man en vrouw. In praktijk zijn experimentele spellen gedaan in de Niayes zone van Senegal, op basis waarvan dit hoofdstuk de man-vrouw verschillen in houding t.a.v. risico is bepaald, alsmede de gevolgen ervan op voor allocatieve inefficiëntie bij de keuze van productiemiddelen en beslissingen over een arbeidscontract, dan wel deelpacht.

De uitkomsten laten zien dat de gemiddelde man of vrouw absolute risicoaversie vertoont in relatie tot marktprijsonzekerheid. Vrouwen zijn niet meer of minder avers dan mannen. Zoals verwacht, en in overeenstemming met het theoretische model, laat de empirie zien dat hogere risicoaversie de allocatieve inefficiëntie in het gebruik van productiemiddelen vergroot. Bovendien bevestigt de empirie dat producenten die meer risicoavers zijn, eerder kiezen voor een deelpachtcontract dan voor een vast arbeidscontract voor hun arbeiders. We geven als beleidsaanbevelingen om maatregelen te treffen die producenten meer risiconeutraal laten zijn en de gevolgen van de risico's voor efficiëntie kunnen temperen.

Al met al voegt dit proefschrift innovatief theoretisch en empirisch materiaal toe aan de literatuur over de economie van het gebruik van productiemiddelen in tuinbouwhuishoudens; met speciale aandacht voor man-vrouw verschillen, risico’s en arbeidscontracten. Naast de wetenschappelijke bijdrage, bevat het proefschrift beleidsaanbevelingen die tot betere economische prestaties van de tuinbouwhuishoudens kunnen leiden, met een leidende rol voor de vrouwen wegens de gunstige uitkomsten voor het welzijn van het huishouden. Groei van de landbouw gedreven door bloeiende tuinbouw is een uitdaging voor economische groei en armoedebestrijding, maar is potentieel haalbaar.

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Aïfa Fatimata NDOYE NIANE

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Curriculum Vitae

Aïfa Fatimata Ndoye Niane was born on November 17th, 1970, in Thies, Senegal. She studied from 1991 to 1996 at the National Superior School of Agriculture (ENSA), at Thies University. She graduated from ENSA with an Agricultural Engineer degree with a major in Rural Economics, with the grade Very Good and an honour diploma.

From 1997 to 1998, she was appointed as researcher at the Senegalese Institute of Agricultural Research/Macro-Economic Analysis Office (ISRA/BAME) and she worked on the Project of Natural Resources Based on Agricultural Research (NRBAR). In this capacity, she was responsible for the socio-economic impacts assessment of research development projects on rural households. After this, she was appointed by Winrock International Senegal in 1998-1999, and made responsible for the monitoring and evaluation of the On-Farm Productivity Enhancement Program (OFPEP). In 1999, Aïfa was awarded a scholarship and acquired a professional diploma at the International Centre for Development-oriented Research in Agriculture (ICRA) in France, after having done fieldwork in Morocco. From 1999 to 2000, she worked at the Ministry of Agriculture, at the Agricultural Policy Unit (UPA), Section Planning and Strategies of Development. From 2000 to 2002, she was appointed as research assistant by the West Africa Rice Development Association (WARDA). Here, she worked on the evaluation, adaptation and transfer of technologies in rural areas in Senegal, Mauritania, and Gambia. From 2002 to 2004, she came back to ISRA/BAME and was responsible for the monitoring and analysis of horticultural producers' economic performance. She was also a consultant expert at the Agency of Funds of Social Development (AFDS) and trainer in Gender and Development. Aïfa wrote several reports and chapters in books.

Since October 2004, Aïfa was a PhD candidate at Wageningen University, in the Development Economics Group, as a scholar of AWLAE (African Women Leaders in Agriculture and Environment) PhD scholarship programme funded by the Dutch Ministry of Foreign Affairs. During her PhD study, Aïfa got the Feminist Development Economics Diploma at the Institute of Social Sciences (ISS). Her PhD focused on gender, labour and risk attitude of producers. Aïfa has presented her research findings at many conferences throughout the world.

Annex to statement
Name Aïfa Fatimata NDOYE NIANE
PhD student, Mansholt Graduate School of Social Sciences (MG3S)
Completed Training and Supervision Plan

MANSHOLT GRADUATE SCHOOL of Social Sciences

Description	**Institute / Department**	**Year**	**ECTS***
Writing Proposal	Wageningen University	2005	**6**
Courses:			
Mansholt Introduction course	Mansholt Graduate School of Social Sciences (MG3S)	2005	1.5
Techniques for writing and presenting a scientific paper	MG3S	2008	1.2
Scientific Writing	Language Center	2005	1.8
Written English	Language Center	2005	1.5
HIV/AIDS and rural livelihoods in Sub-Saharan Africa	MG3S and CERES	2005	3
Gendered Impact of HIV/AIDS in Sub-Saharan Africa	MG3S	2005	3
Microeconomics	Wageningen University	2004	6
Farms, Firms and Rural Networks	Wageningen University	2005	6
Feminist Development Economics Diploma	Institute of Social Studies (ISS), The Hague	2005	8.25
Presentations at conferences and workshops:			
Mansholt Multidisciplinary Seminar: MG3S, Wageningen University		2009	1
Mansholt PhD day, Wageningen University		2009	1
Centre for the Study of African Economies (CSAE) Conference: “Economic Development in Africa”, University of Oxford, UK		2009	1
International Association for Feminist Economics (IAFFE) Annual Conference: “Engendering Economic Policy”, Boston, MA, USA		2009	1
International Association of Agricultural Economists (IAAE) XXVII International Conference : “The New Landscape of Global Agriculture”, Beijing, China		2009	1
Total (minimum 30 ECTS)			**43.25**

*One ECTS on average is equivalent to 28 hours of course work